Akademiya Nauk SSSR

GEOPHYSICAL BULLETIN

No. 13

TRANSLATED FROM RUSSIAN

Published for the U.S. National Aeronautics and Space Administration
and the National Science Foundation, Washington, D.C.
by the Israel Program for Scientific Translations

AKADEMIYA NAUK SSSR
MEZHDUVEDOMSTVENNYI GEOFIZICHESKII KOMITET
Academy of Sciences of the USSR
Interdepartmental Geophysical Committee

GEOPHYSICAL BULLETIN

(Geofizicheskii byulleten')

No. 13

Edited by A. Kh. Khrgian

Izdatel'stvo Akademii Nauk SSSR
Moskva 1963

Translated from Russian

Israel Program for Scientific Translations
Jerusalem 1966

TT 65-50117
NASA TT F-283

Published Pursuant to an Agreement with
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, U.S.A.
and
THE NATIONAL SCIENCE FOUNDATION, WASHINGTON, D.C.

IPST Cat. No. 1403

Translated and Edited by H.I. Needler

Printed in Jerusalem by S. Monson

Price: $ 4.00

Available from the
U.S. DEPARTMENT OF COMMERCE
Clearinghouse for Federal Scientific and Technical Information
Springfield. Va. 22151

IX/18

TABLE OF CONTENTS

NEW PROJECTS AND RESEARCH PROGRAMS

SCIENTIFIC REPORTS AND TECHNIQUES OF MEASUREMENT

REPORTS

INFORMATION

NEW PROJECTS AND RESEARCH PROGRAMS

N. V. Pushkov

PRINCIPAL SCIENTIFIC PROBLEMS FOR THE INTERNATIONAL YEARS OF THE QUIET SUN

The International Years of the Quiet Sun (IQSY) is a new important international project in the field of helio- and geophysics. It is scheduled for the period of minimum solar activity and will last two years — from 1 January, 1964 to 31 December, 1965. Its aim is to ensure joint investigation by the scientists of various countries, of relationships between solar and terrestrial phenomena, and to elucidate the peculiar features of geophysical processes in the period of minimum solar activity.

Unlike the IGY, the IQSY is concerned only with those phenomena which are directly related to solar activity. The IQSY schedule for the period of minimum solar activity continues and complements the IGY, which coincided with a period of maximum activity. Comparison of IGY and IQSY results will make it possible to study the relation between solar and terrestrial phenomena, and also their variation during the entire cycle.

The period of minimum solar activity is most favorable for the study of sun-earth relations. During years of maximum solar activity active formations are generally observed, and it is therefore often difficult to establish which of these is actually responsible for some particular terrestrial disturbance. When almost continuous disturbances are registered, it is difficult to establish when one of them ends and another starts. This is particularly true for such phenomena as magnetic and ionospheric disturbances and disturbances in cosmic rays, which are generally subjected to prolonged after-effects. In years of minimum solar activity there are some periods without any disturbances and other periods with very great disturbances on the sun or the earth. The years of minimum activity are therefore convenient for studying both the quiet and the active states of the sun.

The transition from maximum solar activity to minimum and back is accompanied by various changes in the activity of the sun, in particular, in sunspots. These are observed in the lowest layer of the solar atmosphere accessible to observations, the photosphere. The temperature in sunspots is of the order of 4500°-5000°C, i. e., some 1500°-1000°C below the temperature of the photosphere, and therefore they appear as dark patches on the bright disk of the sun. Their lifetimes vary from several hours to several months. They generally appear in groups, which sometimes comprise dozens of spots of different sizes. Mostly, however, the groups consist of two large sunspots and several smaller ones. The size of sunspots constantly changes. They are small at first, then grow rapidly, and within a few days diminish until they vanish. Sunspots have magnetic fields associated with them. In groups consisting of two sunspots, the so-called leading spot, the one nearer to the eastern limb of the solar disk, always has magnetic polarity opposite to that of the other spot in the group. The magnetic field of a bipolar group is thus analogous to the field of the ordinary horseshoe magnet. The leading spots in the northern and the southern hemispheres of the sun have opposite signs.

The duration of a solar cycle, as measured between two successive cycles, may vary from 8 to 15 years. A new cycle starts with the appearance of sunspots at 30°-40° latitude. The leading spots of the new cycle have a polarity opposite to that of the old-cycle sunspots. In subsequent years the number of sunspots visible on the sun increases, and the latitude of spot formation migrates to the equator. In years of maximum activity the sunspots appear on the average at about 15°-20° latitude. The cycle terminates when sunspots start appearing near the solar equator. The old and the new cycle generally overlap for several years. During this overlap period sunspots are visible in four zones: in two zones of the old cycle, near the solar equator, and in two zones of the new cycles, at high latitudes. This pattern should be observed during IQSY. During this period the leading sunspots of the old cycle in the northern and the southern hemispheres will have N and S polarities, respectively, and vice versa for the sunspots of the new cycle. N polarity corresponds to that which is observed on the north magnetic pole of the earth.

Sunspot activity is generally characterized by a relative sunspot number R. It is defined as $R = f + 10g$, where g is the number of sunspot groups and f the total number of individual sunspots and sunspots in groups. The relative numbers vary from less than ten in the epoch of minimum to several tens in the epoch of maximum solar activity. Thus, during 1933 the yearly average relative sunspot number was 6, and during 1958 over 200.

There are also other solar phenomena which reveal analogous cyclic behavior: these are faculae, flocculi, chromospheric flares, etc. The various solar activity indexes are generally fairly well correlated with one another. For example, the relative sunspot numbers show a high positive correlation with sunspot areas, intensities and areas of flocculi, and also with the number of chromospheric flares.

A satisfactory correlation is observed not only for average values of indexes for more or less prolonged periods, but often also for individual phenomena occurring in different layers of the sun: in the photosphere, the chromosphere, and the corona. It is known, for example, that sunspots are invariably accompanied by faculae, bright photospheric and chromospheric formations whose temperature is several hundreds of degrees higher than the temperature of the photosphere. Faculae may appear without sunspots, but no sunspots form without accompanying faculae.

Similarly, in the chromosphere — the layer situated above the photosphere — there are almost always dark and bright formations — cloud-like calcium and hydrogen flocculi. Flocculi may also appear independently of sunspots, but the strongest and largest flocculi are always observed in sunspot regions only. Chromospheric flares, or eruptions, accompanied by eruptive prominences and short-lived enhancement of ultraviolet, X-ray, corpuscular, and radio emission of the sun also invariably occur in sunspot regions, during the formation and the rapid development of the sunspots. Cyclic phenomena are also observed in the outermost layer of the sun — its corona. In years of maximum long coronal rays are more or less uniformly distributed over the solar limb, while in years of minimum they tend to concentrate near the equator.

From the close relation of the different solar phenomena we may conclude that they are all connected with some general cyclic activity taking place in interior regions of the sun.

The transition from maximum solar activity to a minimum is accompanied not only by a reduction in the number of disturbances, but also by attenuation of solar radiation, at least in the ultraviolet and the radio regions of the spectrum. Ultraviolet radiation is entirely absorbed in the upper layers of the earth's atmosphere, and its energy is totally expended in ionization of upper layers and maintenance of the ozone layer. Until recently the attenuation of ultraviolet radiation was inferred indirectly, from the reduction in the critical frequencies of ionospheric layers during the transition from maximum to minimum. Because of this reduction, radio communication during the years of minimum requires longer waves than during the epoch of maximum. Attenuation of ultraviolet radiation of the sun during the transition from maximum to minimum is also reported by magnetologists from the reduction of the quiet diurnal magnetic variations and of variations of terrestrial currents.

During the IQSY the attenuation of solar radiation will be first studied by direct measurements on satellites and rockets launched to beyond the boundaries of the earth's atmosphere. Of particular interest will be the observations of the "solar constant" and of radiation in ozone absorption bands.

The solar constant specifies the amount of solar energy passing every minute through a surface area of 1 cm^2 perpendicular to solar rays and located outside the terrestrial atmosphere. Measurements of the solar constant near the earth's surface and subsequent extrapolation to the boundary of the atmosphere show that the constant varies during the solar cycle. However, the observed variation, of the order of 1-2 %, is just within the margin of error of the measurements and the result therefore cannot be considered reliable. Earthbound measurements of the atmospheric content of ozone do not reveal a distinct cyclic behavior either, which is possibly due to redistribution of ozone by atmospheric circulation.

The observational data of IQSY will be used for two purposes: (a) to investigate the average regularities governing various solar and terrestrial phenomena, and (b) to study individual sun-earth interactions. Of particular interest is the analysis of phenomena related to chromospheric flares. Flare lifetime is very brief: from several minutes to one hour and a half. They are generally accompanied by overall enhancement of solar radiation and bring about considerable changes on the sun and in interplanetary space.

Owing to the establishment of continuous solar watch, many flares are now observed on the sun during the phase of their development, but it is often impossible to determine the exact onset of the flare. A few minutes after the inception of a flare, solar radioastronomical observatories register a burst, or a solar radio flare. The burst generally starts at wavelengths in the centimeter range, and gradually passes to longer, meter waves.

Simultaneously with solar radio waves, earthbound observatories also receive ultraviolet and X-ray radiation. This radiation creates enhanced ionization in the lower ionospheric layer, at an altitude of 60-90 km, on the illuminated side of the earth. Owing to the high collision frequency of particles in these rarefied, but still comparatively dense atmospheric layers, the free electrons formed during the flare rapidly recombine and attach themselves to neutral particles. Their effect of radio waves therefore ceases soon after the termination of the flare and generally amounts to enhancement of the absorption of short radio waves, which propagate over large distances owing to reflection from upperlying ionospheric layers. This absorption is sometimes high enough to cause total breakdown of short-wave radio communication on the illuminated side of the earth. Since these changes in the ionosphere occur almost instantaneously, they are called sudden ionosphere disturbances. They are accompanied by an enhancement of electric currents flowing in the upper conductive atmospheric layers. This effect is strongest in localities where the sun is near the zenith. Variations in the magnetic fields of these currents are recorded by magnetic observatories.

A few hours after a major solar flare, strong absorption is often recorded in north and south polar caps. It is no longer due to ultraviolet and X-ray solar radiation, but rather to a flux of solar cosmic rays consisting of protons and hydrogen nuclei ejected from the sun during the flare. Their energy is lower than the energy of galactic cosmic rays (and therefore they arrive at the high latitudes only), but it is nevertheless sufficient for these particles to penetrate the atmosphere to depths of 30 km and even less. Here they are registered by charged-particle counters launched on sounding balloons. They are also recorded by riometers which show an enhanced absorption of cosmic radio noise. These particles also affect the absorption of high-frequency radio waves, which propagate due to scattering in the lower ionosphere.

The energy of solar cosmic rays is sometimes high enough for these flares to be registered not only at high latitudes, but by all cosmic ray observatories.

A day and a half or two days after some of the flares, magnetic storms and ionozpheric disturbances are observed on the earth, accompanied by intense polar aurorae which, during magnetic storms, also appear in the lower latitudes. During very strong magnetic storms, aurorae are observed almost on the equator. Strong storms are often accompanied by substantial attenuation of galactic cosmic rays. During major ionospheric disturbances the height of the upper layers of the ionosphere increases and ionization density in these layers near the equator becomes higher, while decreasing in middle and high latitudes. It is assumed that the increase of ionospheric height is due to the heating of the upper atmospheric layers during magnetic storms. The variation of density of the upper atmospheric layers also affects the orbital velocity of artificial satellites.

The large and rapid magnetic-field variations during magnetic storms increase the electric currents induced in the upper layers of the earth's crust. They sometimes become strong enough to interfere with the operation of single-wire telegraph lines, where the earth is used as the return wire.

Magnetic storms and some related phenomena are closely connected with the influx of solar corpuscules, protons, and electrons ejected during the flares from the active zones on the sun, but moving more slowly than solar cosmic rays, into the radiation belts of the earth. The time between the occurrence of the solar flare and the onset of the magnetic storms indicates that these corpuscules move with velocities of some 3000 km/sec.

It is assumed that solar corpuscular streams may remove part of the solar magnetic field and therefore retain particles of various energies. Most of the solar particles approaching the earth are trapped by the magnetic force lines and form the radiation belts of the earth. Particles of lower energy are trapped at greater distance from the earth, while those of high energy penetrate closer to the earth. Part of the stream possibly reaches the upper atmospheric layers in polar regions, bypassing the radiation belts. Particles from radiation belts also eventually wind up in these regions, having infiltrated the atmosphere along the geomagnetic force lines. Polar aurorae in high altitudes are therefore visible not only during magnetic storms, but virtually daily.

Radiation belts were only discovered during the IGY. The satellite and rocket research planned for the IQSY is therefore of particular interest. Possibly, the change in radiation belts between maximum and minimum solar activity is very substantial.

The study of the relationship of solar and terrestrial phenomena at the present stage is possible only by a joint effort of scientists of various disciplines in various countries who will undertake to carry out, according to a single program, a large number of observations at numerous solar and geophysical stations and observatories in various parts of the world. Of considerable significance are observations in high magnetic latitudes, and primarily in antipodal stations and observatories, i. e., those situated at the opposite ends of one magnetic line. Examples of such conjugate pairs of stations are provided by the Soviet station Vostok in the Antarctic and the American station Thule in Greenland, both situated at the geomagnetic poles, or the two Soviet observatories in Mirny and in Murmansk. Parallel observations should be made at these stations, following as wide a program as possible of observation of polar aurorae, solar cosmic rays, magnetic, ionospheric, and other phenomena related with upper atmospheric layers.

Of exceptional significance for the study of solar-terrestrial relationships will be the work in interplanetary space, in radiation belts, and in the upper atmospheric layers, to be carried out by means of satellites and rockets, and the coordination of the results of these projects with terrestrial observations. Solar-terrestrial relationships can be explained only when we know what solar agents are responsible for various particular terrestrial phenomena. Earthbound observations alone cannot reveal the true nature of these phenomena, since only part of the ~~solar~~ radiation reaches the surface of the earth. For example, X-rays and most of the ultraviolet radiation of the sun are absorbed in the upper layers of earth's atmosphere, the long solar radio waves are screened off by the ionosphere, and corpuscular radiation is trapped by the magnetic field in the radiation belts.

In so far as there are no reliable data concerning the solar agents, some ten hypotheses have been advanced attempting to explain the nature of magnetic storms and polar aurorae. During the IGY, satellites and rockets made it possible to obtain reliable data by direct measurements of solar agents and their effects in cosmic space and in the upper atmospheric layers. Our knowledge of these phenomena have consequently become more thorough.

After the IGY the possibilities of carrying out observations in outer space became much greater. The research program can also be made more manifold than the IGY program. The choice of particular projects to be carried out with rockets and satellites during the IQSY has been repeatedly discussed by the International Committee of Space Research (COSPAR). There are so many suggestions, that it will be impossible to put them all to practice, although the number of countries with advanced rocket-research technology has considerably increased, and satellites will be launched not only in USSR and U. S. A., but also in Canada and England in cooperation with France and West Germany.

It is suggested that during the IQSY the solar survey will be undertaken not only by earthbound stations, but also by special "patrol" satellites whose automatic instruments will record and transmit to the earth data on the variations of solar radiation. These satellites will stay aloft for long periods, recording solar radiation in various spectral regions. It is also proposed to launch satellites with a highly elongated elliptic orbit, with semimajor axes of several tens of earth's radii. These satellites will be equipped with magnetometers and various counters for registering the number of protons and electrons of various energies. The purpose of these satellites is to collect information on the interaction of solar corpuscular radiation with the terrestrial magnetic field and on the structure of the radiation belts of the earth.

There is an assumption that the solar corpuscular radiation may have a wind-like effect. Blasts of solar wind during chromospheric flares may distort, break, and carry away magnetic force lines of the sun. They may also compress the terrestrial magnetic force lines on the windward, day side of the earth, while breaking and bending some of the lines of the leeward, night side. The solar wind will so distort the earth's magnetic field that at large distances it will no longer behave, as has been previously maintained, like a magnetic dipole field. The magnetic field of the earth, and also the outer radiation belt, will behave like comet tails, i. e., will be always elongated in a direction away from the sun. This assumption can be verified only with long-lived satellites with highly eccentric elliptical orbits. During the annual revolution of the earth about the sun, these satellites in some cases will be continually illuminated by the sun or may cross the boundaries of the magnetic field and the outer radiation belt on the day and the night sides of the earth.

During the IQSY satellites will also be used for other scientific purposes. Meteorological satellites will furnish information on the cloud cover of the earth and on the amount of radiation reaching and leaving the earth. The program of meteorological satellites will possibly be expanded during the IQSY to include observations of nighttime, as well as daytime, cloudiness, and also recording to thunderstorm activity, polar aurorae, and atmospheric ozone contents.

Satellites will also be used for worldwide magnetic mapping. The data obtained in this way will improve the magnetic charts on oceans in polar regions, and in other parts of the earth where ordinary mapping methods are not particularly successful. There is a suggestion that satellite mapping will enable the bedding depth of the sources responsible for regional and global magnetic anomalies to be determined with higher accuracy.

Very interesting data on the critical frequencies of the ionospheric F2 layer and on the hitherto unknown structure of the ionosphere above the electron concentration maximum of the F2 layer can be obtained by means of satellites equipped with ionospheric stations. These satellites will sound the ionosphere from above. Those observations will make it possible to arrive at more accurate predictions of the working frequencies for radio communication and to introduce proper corrections to these frequencies during ionospheric disturbances. These observations will acquire special significance in calculation of working waves for communication with aircraft and satellite ships.

At present many various investigations of the near-terrestrial and interplanetary space are in progress. Some of them will be undoubtedly continued or repeated during the IQSY It clearly follows from the preceding that the IQSY program of space research will be of greater extent and will cover a greater variety of subjects that the IGY program. It should also be expected that terrestrial observations of cosmic, solar, and geophysical phenomena will be more comprehensive and more accurate than those carried out during the IGY, i. e., at the initial stages of these research projects.

One of the principal problems of solar activity research during the IQSY will be to ensure continuous solar patrol in the optical and the radio regions. Continuous solar survey is possible only under conditions of international cooperation, when the solar watch is passed from one country to another from east to west. The results of solar patrol will be used for correlation of solar and terrestrial phenomena. These data will also be required for predicting active and quiet periods on the sun, during which geophysical observations will follow special programs.

Satellites make it possible to register not only the strong, but also the very weak solar phenomena occurring in the upper layers of the earth's atmosphere. The IQSY program will therefore include the study of weak, as well as prominent, solar phenomena. Moreover, measurements will be taken not only of the strong magnetic fields of the sunspots, but also of the weak magnetic fields over the entire solar disk. Solar magnetic fields are highly significant in all solar phenomena connected with the motion and ejection of charged particles by the sun. Measurements of the weak magnetic fields will furnish valuable data for the study of the general magnetic field of the sun. The general solar magnetic field is no stronger than 2 gauss, while the intensity of sunspot fields may be as high as several thousand gauss. The magnetic interference of the sunspot fields precludes the observation of the general solar field during the epoch of maximum at latitudes lower than $\pm 60°$, while in the epoch of minimum it can be observed even near the equator.

The IQSY program should make provision for expansion of chromospheric and coronal observations, in particular observation of calcium flocculi in K emission. Terrestrial coronal observations will possibly be supplemented with observations of white corona light from balloons, satellites, and rockets. The distant parts of the outer corona will be further studied by observing the eclipse of galactic radio sources.

The research of the radioelectric activity of the sun, besides dealing with constant frequencies, should concentrate more on spectral measurements over a wide frequency range by means of radiospectrometers. Minimum solar activity opens new vistas for the study of solar radio emission in longer waves than was possible during the IGY. However, more powerful antennas are required to this end, since the intensity of solar radio waves is lower in this epoch. The IQSY will also be favorable for the study of the outer solar atmosphere by radar methods from the earth.

Unlike the IGY, the meteorological program of the IQSY does not provide for the study of the surface layer of the earth's atmosphere, since numerous comparisons of solar activity with meteorological processes in the surface layer have not yet established any definite relationship between the two factors. If there is some relationship, it should have an indirect nature and be realized through the certain interactions between the upper and the lower atmospheric layers. The relationship between solar activity and the upper layers have by now been established not only by ionospheric and magnetic observations, but also by tracking the orbital motion of satellites. Variation of their orbital velocity enable the air resistance and its density to be determined at the corresponding altitude. Comparison of these data obtained during IGY and subsequent years shows that the density of the upper layers decreases between maximum and minimum solar activity. This may be due to the decrease of the temperature of the upper atmospheric layers following the drop in solar activity. Satellite tracking also showed that the density of the upper atmospheric layers increases during chromospheric flares. This may be due to the heating of the atmosphere at that time.

The aim of the IQSY meteorological observations will be to investigate the physics, dynamics, and thermodynamics of the upper atmospheric layers, and also the relationship of the upper and the lower atmospheric layers in the epoch of minimum solar activity. Besides ordinary radio-sounding balloons, whose roof altitude constantly increases, meteorologists have now at their disposal special meteorological rockets, a very powerful, though rather restricted, means for measuring air temperature, pressure, and motion from the surface layer up to 60-120 km, i. e., up to the mesosphere and thermosphere. Special-purpose radio-sounding balloons have also been developed, intended for measuring solar radiation, atmospheric ozone, electric-field gradient, and electric conductivity of the atmosphere. Solar and terrestrial radiations will also be measured, as previously mentioned, by meteorological satellites.

IQSY meteorological observations will be mainly confined to aerological and actinometric measurements and observations of atmospheric ozone. Special programs also provide for a study of the water-vapor distribution in the upper atmospheric layers. Water vapor, like ozone, is a highly significant factor in the radiative balance of the atmosphere and serves as an excellent tracing element in the study of atmospheric circulation.

Valuable data on circulation in the mesosphere will be obtained from observations of noctilucent clouds, which form, as we know, at altitudes of some 80 km. These data will also be interesting for specialists studying high-altitude winds (in ionospheric E and F layers) by radio methods.

The meteorologists have worked out a calendar of world days and world geophysical intervals. The former will take place on Wednesdays of every week. The latter are scheduled for January, April, July, and October, 1964, and January, March, June, September, and December, 1965. The duration of each interval will be two weeks. They are scheduled to take place on the second and the third week of the specified month, starting on Monday. The greatest number of observations in these intervals will be made on Wednesdays.

Highly important scientific and practical results can be obtained by the ionospheric studies planned for the IQSY. Some subdivisions of this ionospheric program, e. g., distribution of electron concentration in the near space, radio-wave absorption in the ionosphere and atmospheric radio disturbances, have a direct bearing on future design and exploitation of various means of radio communication and radio navigation.

Ionospheric research is a comparatively young, but rapidly developing, branch of geophysics. Many stations, due to take part in the IQSY observations, were erected after 1945, while some of them were commissioned in connection with the IGY. The number of stations and their distribution over the globe do not satisfy practical requirements. Ionospheric data relating to minimum solar activity have until now been collected by few stations only; in the Antarctic they will be obtained for the first time during the IQSY. IQSY observations encompassing as large a network of ionospheric stations as possible is therefore one of the basic problems. Of particular interest are ionospheric observations in oceanic regions — on oceanographic research vessels and meteorological service ships.

It is noteworthy that the scantiest information is available on the lowest ionospheric layer, the D layer, located at an altitude of from 60 to 100 km, although it plays a highly significant role in the propagation of short, and, particularly, long radio waves. This is so because it cannot be studied from ordinary ionospheric stations. The ionization density of this layer is low, and to obtain reflection from it in cases of vertical incidence, powerful pulses of very low frequencies are required; these cannot be generated without large aerials and powerful transmitters. The IQSY program therefore recommends that this layer be studied by rockets at four points. Two points should be located in moderate latitudes of the northern and the southern hemispheres, the third on the magnetic equator, and the fourth in the zone of polar aurorae. Measurements can be made from small rockets with a maximum altitude of up to 160 km, which thus covers ionospheric D and E layers only. The rockets must be launched at all stations on the same day, once every three months. It is recommended to launch six rockets on every synoptic day. Since D and E layers exist only during the daytime, the rockets are to be launched during the day at certain specified solar zenith angles.

The rockets should preferably be equipped with a set of instruments for simultaneous measurements of ion and electron concentrations, ultraviolet and X-ray radiation of the sun, magnetic field, and some other elements. The launching of rockets should be accompanied by terrestrial measurements of magnetic field, galactic radio noise, and critical ionospheric layers.

One of the main problems in the study of the upper ionospheric F_2 layer is the study of worldwide distribution of electron concentration over the height and of its variation with the time of the day, the season, the state of solar activity, and other factors. Measurements carried out at ionospheric stations do not give the true heights of electron concentration. It can only be obtained by complicated computer work from observations.

A study of radio signals of various frequencies transmitted by the satellites, and also observations of galactic radio waves at various frequencies will yield much valuable data on the ionosphere extending above the F_2 maximum. Satellite sounding of the ionosphere from above will give information on the ionospheric structure in these layers and its variation.

In connection with the study of radiation belts of the earth, considerable attention will be paid to whistler atmospherics, i. e., low-frequency electromagnetic oscillations (300 cycles and lower) generated by lightning discharge. Unlike ordinary atmospherics, also generated by lightning discharges, the whistlers do not propagate along the earth's surface, between the ionosphere and the earth, but rather follow the forcelines of the geomagnetic field. They can therefore be received only at magnetically conjugate points relative to the point of the lightning discharge; they moreover arrive at these points much later than the ordinary atmospherics, having traversed a longer path. Whistlers often travel several times from one hemisphere to another. Their spectral characteristics depend on the distribution of electrons over the magnetic force lines. A study of those characteristics may yield some information on the distribution of electron concentration in radiation belts at very great distances from the earth. During the IQSY whistler atmospherics will also be studied from satellites.

Of no lesser scientific interest is the study of electromagnetic oscillations of still lower frequencies observed in high latitudes. Their origin is still not clear. They show a certain correlation with polar aurorae and with magnetic and ionospheric disturbances, and they are therefore assumed to result from an as yet unknown mechanism activated by the penetration of charged particles from the radiation belts into the ionosphere.

IQSY ionospheric observations should be carried out by methods of backward oblique sounding, forward oblique sounding, diffusive propagation of meter waves. These methods will enable us to form a better picture of the long-distance propagation of radio waves. Observations of the propagation of meter radio waves in the Arctic and the Antarctic may yield valuable information on the effects of polar absorption due to the influx of charged particles to the polar caps. During the IQSY it is recommended that the study of the lower ionosphere be continued also by photographic and radio-echo observations of meteors.

In certain observations, the ionospheric parameters are measured by several methods. For example, absorption is measured by three different methods, ionospheric winds by four methods, including radio-echo tracking of meteors. There are also several methods available for measuring certain ionospheric parameters from rockets. Each of these methods has its characteristic advantages and shortcomings. Different methods are often used in different countries, and the results are therefore not quite comparable. In order to provide a standard of comparison, it is recommended that measurement at certain observation points should be carried out by several different methods. Launching sites of geophysical rockets are the most suitable in this respect.

The study of the emission of nighttime and twilight sky is one of the means for gaining information on elementary processes occurring in the upper atmospheric layers due to dissociation and ionization of atoms and molecules by the action of ultraviolet and corpuscular solar radiations and subsequent recombination. The spectra of nighttime and twilight sky glow enable the composition of the gases and the temperature in the upper atmospheric layers to be determined. Observations of the variation of sky glow intensity may in future yield data on air motion in the upper atmosphere. The night sky glow is much weaker than polar aurorae, but the spectra of the two phenomena have much in common. Therefore systematic recording of night sky glow at more or less high latitudes is impossible for all practical purposes during the epoch of maximum solar activity, since it is often obliterated by polar aurorae. During the IQSY the auroral activity will be lower and the study of night and twilight sky glow can be advanced to higher latitudes. During the IQSY it is recommended to measure the night sky emission intensity in the following spectral lines and banks: 6300 Å, 5577 Å, 5892 Å, and the OH band. Scanning photometers are the most suitable to this end, since they are designed for making fast measurements over the entire sky, along several lines simultaneously. To obtain data on the geographic distribution of glow intensity, it is recommended to carry out aircraft measurements of the 6300 Å emission. It is also possible to carry out simultaneous measurements at all the stations of the network of the temperature of the upper atmosphere from the structure of OH bands. Individual research programs also include rocket measurements of the heights at which sky glow originates, and daytime and twilight measurements of the sodium emission intensity.

All that we have previously said on the application of night sky glow to the study of upper atmospheric layers is equally, and possibly even more, true for polar aurorae. Aurorae are excited by particles reaching the upper atmospheric layers along the geomagnetic forcelines from the radiation belts. Observation of polar aurorae can therefore yield valuable information on the state of the radiation belts. However, first it is necessary to carry out numerous comparative measurements of polar aurorare with phenomena known to occur in radiation belts.

Systematic study of polar aurorae has until now been confined to the zone of highest auroral frequency, to the very few observatories in Norway, Canada, the U. S. A., and the USSR. No observations were made in the southern hemisphere. Prolonged observations yielded a large body of data on auroral frequency, their altitudes, spectra, etc. As yet, no data are available on the variation of auroral characteristics with latitude inside and outside the zone of polar aurorae and during the solar activity cycle. Observations in the Antarctic gave more or less reliable data on the frequency of distribution of polar aurorae in this region in the epoch of maximum solar activity only; information on the distribution of aurorae in the epoch of minimum will be collected during the IQSY.

During the IGY highly valuable information of polar aurorae was obtained by means of a new technique: automatic cameras photographing the entire sky, high-sensitivity patrol spectrographs, radar, etc. No less important results were obtained by simple visual observations of polar aurorae on a network of meteorological stations. Had synoptic meteorological stations practiced a more detailed recording of the visible polar aurorae prior to the IGY, the data obtained would have enabled various peculiarities of polar aurorae as a planetary phenomenon to be elucidated. In particular, it would have been possible to establish the migration of the auroral zone during the solar cycle, the number of auroral zones (whether one or two) in each hemisphere, etc. Without data on visual observations of polar aurorae it is impossible to carry out a reliable comparison of what we know on polar aurorae with the data on radiation belts. To this end it is also essential to carry out compatible observations of auroral hydrogen emission at magnetically conjugate points and at a wide network of stations. As much information as possible should be collected on the velocities of protons in polar aurorae at various geomagnetic latitudes. Exceptionally valuable material can be obtained by photometric measurements from satellites.

Simultaneously with the study of polar aurorae as a planetary phenomena, it is also necessary to study the mechanism of their excitation, relation to magnetic and ionospheric phenomena, radio-wave absorption and reflection by the aurorae, etc. The study of aurorae from rockets must also be continued.

Geomagnetic variations constitute one of the most sensitive indicators of solar phenomena. To a certain extent this is so because the magnetic field intercepts streams of solar corpuscules already at very large distances from the earth. The streams should be highly conductive, because they consist of charged particles. When the corpuscular streams penetrate into the magnetic field, electric currents are induced in them which may disturb the magnetic field of the earth. It is also assumed that the reduction of the geomagnetic field strength during worldwide magnetic storms is due to the action of the annular current flowing around the earth from east to west at a distance of several terrestrial radii.

Electric currents may also arise in the conductive ionosphere when it moves in the geomagnetic field under the action of tidal forces, heat expansion, and other factors. Ionospheric currents are responsible for the quiet solar-day and lunar-day variations of the magnetic field. Fluctuations in this system of ionospheric currents may also result in magnetic disturbances. These phenomena arise in cases of enhanced ionization on the day side of the earth during sudden ionospheric disturbances, but mostly they occur in high magnetic latitudes due to the influx of charged particles from the radiation belts or directly from the sun. Various phenomena are then observed in the ionosphere and in polar aurorae, in particular, a special kind of magnetic disturbances called elementary polar storms or bay disturbances.

Geomagnetic field disturbances may occur at its boundary also in the absence of solar streams, when the earth moves in the conductive interplanetary plasma. In these cases the disturbances are small and are recorded simultaneously all over the world or over a large part of the earth. In this class we have certain micropulsations of the magnetic field and of terrestrial currents. There are also other pulsations, with a much greater period and amplitude, the so-called giant pulsations. They are observed over limited areas in polar regions and show a correlation with variations in polar aurorae and in the ionosphere.

IQSY conditions are favorable for the study of quiet diurnal variations, magnetic micropulsations, and bay disturbances, which are generally masked by strong magnetic storms. The joint study of quiet magnetic variations and ionospheric changes will make it possible to investigate the reasons for the daily alteration in the system of currents of the quiet diurnal variations. Magnetic-field measurements from rockets will also help in this direction. They will enable us to establish in what layers these currents flow and how their density varies with altitude. The measurements are scheduled to be made primarily on the magnetic equator and in auroral zones, where the density of ionospheric currents is the highest.

Much is expected from satellites. They will be used to perform magnetic mapping and to investigate the extra-ionospheric system of currents. It is also proposed to record on satellites the magnetic micropulsations with the object of establishing the region of their origin.

High-speed recording of terrestrial currents during the IGY showed that data obtained can be successfully applied to the study of electromagnetic field micropulsations. During the IQSY an attempt will be made to extend this research to pulsations of still shorter periods, from 0.1 to 15 sec. Joint consideration of magnetic-field and terrestrial-currents variations may yield valuable information on the electric conductivity of the earth's crust at great depths. One of the principal divisions in the IQSY program calls for the study of cosmic-ray variations — variation in their intensity, energy spectrum, and composition. Cosmic-ray research may throw light on the electromagnetic conditions prevailing outside, as well as inside, the solar system.

Cosmic rays, as we know, are high-energy charged particles, mostly protons, reaching the earth from the sun during flares, and constantly from the direction of the galaxy. They possess tremendous energies. These particles cannot be generated even in the most powerful of modern accelerators. Highest energies are characteristic of the galactic rays. Their energy is several orders of magnitude higher than the energy of solar cosmic rays. Possibly, galactic rays are generated in supernova explosions; they could also form in certain electromagnetic phenomena, not unlike solar flares, and be subsequently accelerated by stellar and interstellar fields by means of some as yet unknown mechanism.

When moving through the galaxy the cosmic rays are repeatedly scattered by irregular magnetic fields set up by the interstellar matter. In time they therefore start moving in all directions with equal intensity. However, when this flux reaches the sphere of influence of the regular geomagnetic field, it becomes anisotropic, since the field deflects the particles from the initial direction. Cosmic rays consequently acquire various magnetic effects: latitude and longitude effects and east-west asymmetry. These effects become more pronounced as the energy of the particles decreases.

The intensity and the spectrum of primary cosmic rays may be altered by an encounter with a stream of solar particles retaining the magnetic field of the sun. These streams may, as we have already indicated, produce magnetic storms accompanied by a decrease in cosmic ray intensity (Forbush effect). A considerable part of the primary cosmic rays is absorbed in the earth's atmosphere. Most of the particles registered near the surface of the earth are secondary, generated in the earth's atmosphere due to nuclear reactions between the primary cosmic rays and the air atoms and molecules. It was calculated that only ten primary particles are required to generate a million secondary particles at sea level. Secondary rays, mostly mesons and neutrons, possess lower energy than the primary rays.

A study of the variation of cosmic rays in time made it possible to distinguish between several kinds of temporal variations. Some of those are periodic, the others being irregular. Among the former we have the solar-day and the sidereal-day variations, seasonal fluctuations of the variation of cosmic-ray intensity during the solar-activity cycle, and also 27-day variations. Among the irregular variations we have meteorological effects, cosmic-ray enhancement during solar flares, and the Forbush effect.

Since cosmic rays are absorbed and generated in the atmosphere, their intensity should vary depending on meteorological conditions. To make some inference on the influence of extraterrestrial factors on cosmic rays, the cosmic-ray count must be corrected for atmospheric pressure and temperature when measuring the meson component and for pressure when measuring the neutron component. Data necessary for these corrections are borrowed from radio-sounding observations of aerological stations located near the cosmic-ray station. The correcting techniques now available require further refining. The IQSY is the most suitable time for this, since the conditions on the sun and in interplanetary space are then the quietest, so that the meteorological effects can be isolated in pure form. For the same reason the IQSY is particularly favorable for the study of the low-energy part of the primary cosmic ray spectrum. IQSY data will possibly help to decide the issue of the questionable sidereal-day variations. Some scientists, in their observations during previous epochs of minimum, detected these variations. However, their amplitude comprises but one hundredth of the amplitude of the variations produced by meteorological factors, and the result therefore cannot be accepted without further reservation. If these variations will be detected, the galactic cosmic rays will be regarded as partly isotropic. Individual sources of galactic radiations may possibly be isolated as being responsible for the sidereal variations.

Although the yearly average intensities increase during the epoch of minimum, the other variations decrease conversely. Therefore, the amplitude of the solar-day variations, the 27-day variations, and the east-west asymmetry during the IQSY will be less than during the IGY. In this connection, the instruments now in operation will be supplemented, in the Arctic and the Antarctic, by a small number of instruments of a new type — supermonitors, enabling neutron count to be taken with much higher speed than the ordinary neutron monitors. It is also proposed to increase the meson counting rate by introducing plastic scintillation counters. Higher counting rates will be most helpful in registering Forbush effects. These effects are only observed during some of the magnetic disturbances, and it is impossible to establish any relation between the intensity of the magnetic disturbance and the strength of the Forbush effect. Reduction of cosmic ray intensity may sometimes coincide with the onset of a magnetic disturbance, while in other cases it may precede it or lag behind. The recovery of cosmic-ray intensity to normal values after the disturbance generally takes more time than the recovery of the magnetic field.

The existing hypotheses try to attribute the Forbush effect to the action of solar corpuscular streams on primary cosmic rays. Those hypotheses propose various models of corpuscular streams, which in some cases are highly divergent.

Satellite measurements of cosmic rays should help in testing the veracity of these hypotheses. Only then will it be possible to infer the corpuscular stream properties from the nature of the Forbush effect.

Major cosmic-ray bursts during the IQSY are not very probable, but not impossible. As regards moderate and minor bursts, they will be observed on satellites and sounding balloons at high latitudes. Valuable information on the behavior of high-energy particles in the epoch of minimum solar activity can be obtained from observations of extensive air showers and by underground counting of cosmic rays.

The IQSY will make it possible to collect an enormous body of highly valuable data, which, together with the IGY materials, will be used as the basis for many a research project.

The IQSY program will enlarge and extend our knowledge of various geophysical phenomena and their relationship with solar phenomena, and this will enable us to achieve better results in applying our knowledge to practical purposes.

N. N. Sysoev

THE INTERNATIONAL OCEANOLOGIC EXPEDITION IN THE INDIAN OCEAN

During the 1955 meeting of the Consultative Committee on Marine Sciences in Tokyo, the question was first raised of the study of the Indian Ocean, one of the least studied equatorial regions. During 1958 it was decided to dispatch an International Indian-Ocean Expedition. The timetable of this expedition was repeatedly revised, and at present the expedition is officially regarded to cover the 1960-1964 period, although in practice the study of the Indian Ocean was begun earlier.

Between 1955 and 1958, a Soviet vessel, the R/V "Ob'", operated in the Indian Ocean, carrying out extensive comprehensive research (the sea routes of the Soviet vessels for the 1955-1961 period are shown in Figure 1). During the IGY (1957-1959) French and American vessels also made research cruises in this area.

Twenty countries were invited to take part in the study of the Indian Ocean: Australia, Britain, India, Indonesia, Pakistan, the USSR, the U.S.A., France, West Germany, Japan, the Republic of South Africa, and others. These countries carried out observations on 40 research vessels. Some 60 sea routes taking from 1 to 12 months to cover the area are scheduled for the duration of the expedition. The main research work is due to take place to the north of 40°S latitude. During the 1959-1961 period the participant countries will undertake to carry out various national research projects and to coordinate to a certain extent their plans of research. Countries which do not intend to dispatch vessels to this expedition will proceed with meteorological research and tidal observations. Among these countries and territories, in addition to those listed above, are Burma, South Vietnam, Iraq, Kenya, Mauritius Island, Malaya, Malagasy Republic, Mozambique, Singapore, Thailand, Ceylon, and Ethiopia. Observations will also be made on Laccadive, Maldive, and Seychelles islands (England), on the Amsterdam and Kerguelen islands (France), and on the Andaman Islands (India). The preparation of the International Indian-Ocean Expedition was undertaken by the Special Committee of Oceanographic Research (SCOR). UNESCO participates in the actual organization of the expedition.

During the 1955-1961 period Soviet vessels in the Indian Ocean carried out oceanographic research over the sea routes marked in Figure 1.

During the voyage of the R/V "Ob'" according to the IGY program in 1955-1958, various incidental studies and special observations were made on board along 20°E longitude, which were then applied for calculating the water exchange in the antarctic zone of the ocean. Between 1956 and 1957 the "Ob'" performed two meridional sections through the entire Indian Ocean following an extensive program of observations, including meteorological, physicochemical, biological, and geological studies, and also collected colloidal particles by separation and membrane filtration.

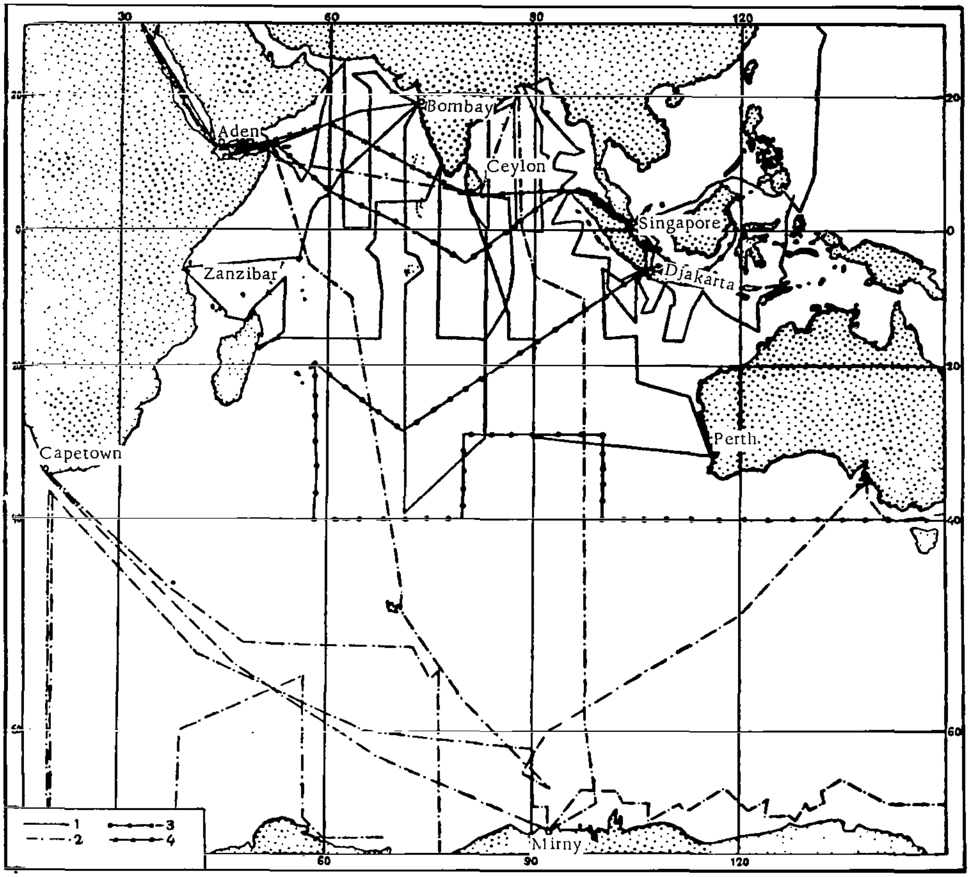


FIGURE 1. Sea routes of Soviet research vessels in the Indian Ocean during 1955-1961

1 — "Vityaz'"; 2 — "Ob'"; 3 — "Shokal'skii"; 4 — "Voeikov."

The expedition vessel,"Vityaz'", traversed three routes of 7, 6.5, and 5 months duration, respectively, between 1959 and 1962, carrying out meteorological, geological, geophysical, physical, chemical, and biological research. Among the methods generally applied on board the "Vityaz'" on these routes, we should mention the method of differentiation for measuring currents at depths of up to 5 km and the method of measurement from anchor buoys at depths of up to 2.5 km. Echo soundings were carried out during the entire voyage. Geophysical measurements were made of the thickness of the sedimentary layers and of the structure of the bottom by means of seismic radio buoys. The Mohorovicic boundary was reached in these measurements. An investigation of the layer of oxygen minimum in the Arabian Sea and the Bay of Bengal gave interesting data on the contamination of this layer with hydrogen sulfide. In some parts of the ocean rich pasture fields and commercial fish populations were charted.

Research students from countries bordering the Indian Ocean participated in the 1962 voyage. During August, near the Australian coast, international calibration of chemical-determination methods and determination of a primary photosynthetic product from C^{14} was carried out on board "Vityaz'". Scientists from the USSR, Australia, the U. S. A., and Japan took part in this work.

The Soviet ships "Voeikov" and "Shokal'skii" also operated in the Indian Ocean. Between 1959 and 1961 standard physicochemical determinations were made aboard these ships.

Some results of research work obtained during the voyage of Soviet ships in the Indian Ocean have been published; the bibliography is given at the end of the article.

During the 1958-1961 period, U.S.A. oceanographic vessels (Figure 2) were occupied in the Indian Ocean mainly with geological and geophysical research, and also carried out physicochemical measurements.

The "Monsoon" expedition (1960-1961) made seismic, bathymetric, gravitational, and magnetic observations, studied the hot currents, sedimentation, etc.

During the same period the U. S. A. undertook geophysical investigations in the Arabian Sea, and in particular, detailed measurements in the Persian Gulf and near the Pakistani coast (1960-1961). The main object of these works was apparently oil prospecting.

Between 1959 and 1961 considerable oceanographic work in the Indian Ocean was carried out by French and Australian scientists (see Figure 2).

French vessels operated in coastal regions of the western part of the ocean, carrying out echo soundings and physicochemical and biological work. Australian ships at that time were mainly concerned with physicochemical and biological research, in conjunction with echo sounding.

Between 1961 and 1962, English, Pakistani, Japanese, and South African expeditions also operated in the Indian Ocean.

The most extensive and best developed research program of the Indian Ocean for 1963-1964 is that of the U. S. A. Scheduled voyages of some countries (e. g. , Australia) have not been announced. Some programs, in particular the Soviet one, have been published in part. It should be emphasized that the Indian-Ocean research program for 1962-1964 is poorly coordinated and on the whole presents the sum total of individual programs of 12 countries. The efforts of SCOR directed toward creating a common research program, which would also provide for a study of seasonal variations in the Indian Ocean, proved insufficient. We must state that the scheduled participation of the Soviet scientists in this expedition for the 1963-1964 period is insufficiently active.

The published plans of American scientists make provision for a considerable number of voyages entailing a fleet of 11 ships, some existing and some in construction. The basic research projects of the U. S. A. are scheduled for the central and the western parts of the ocean (Figure 3). The programs of these voyages allot considerable space to geological and hydrophysical research, echo sounding, and also biological studies.

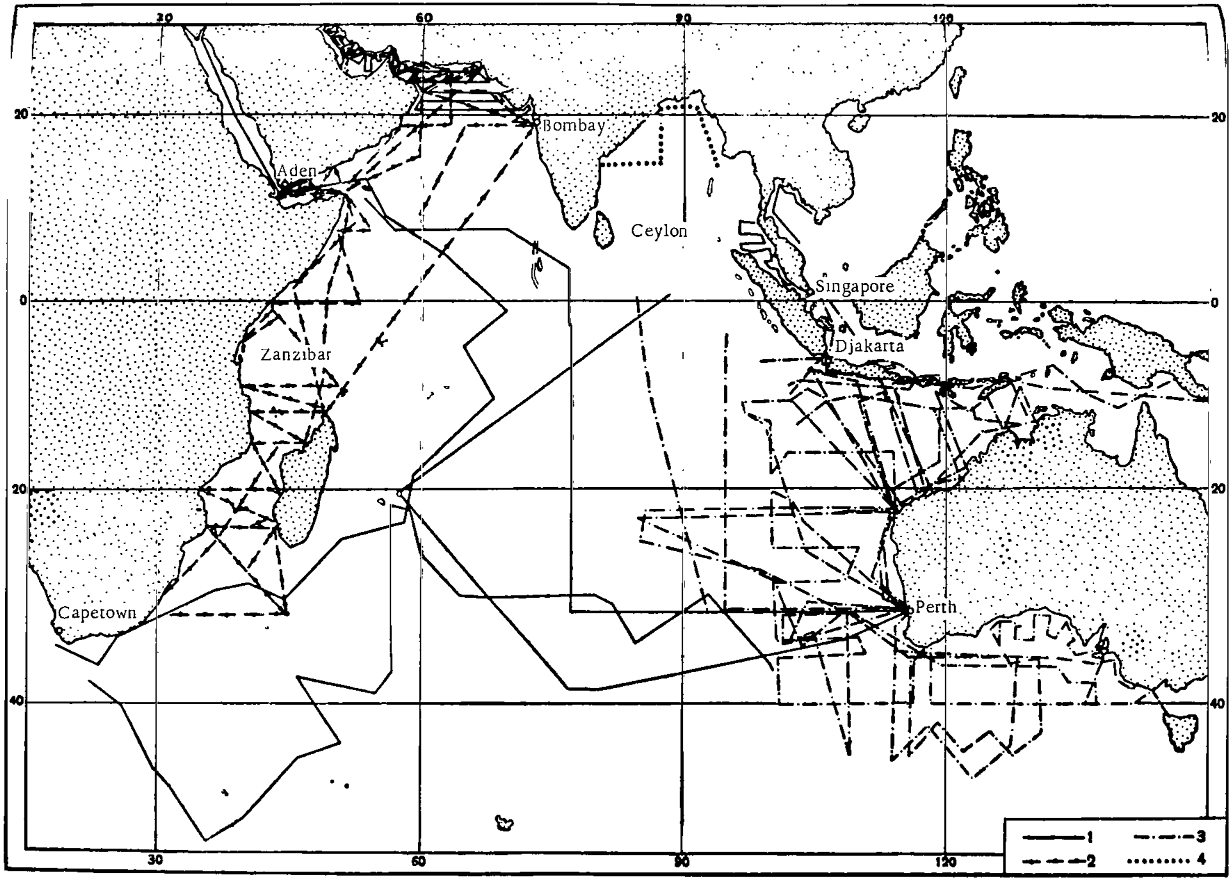


FIGURE 2. Sea routes of non-Soviet research vessels in the Indian Ocean 1958-1961

1 — U. S. A; 2 — France; 3 — Australia; 4 — Pakistan.

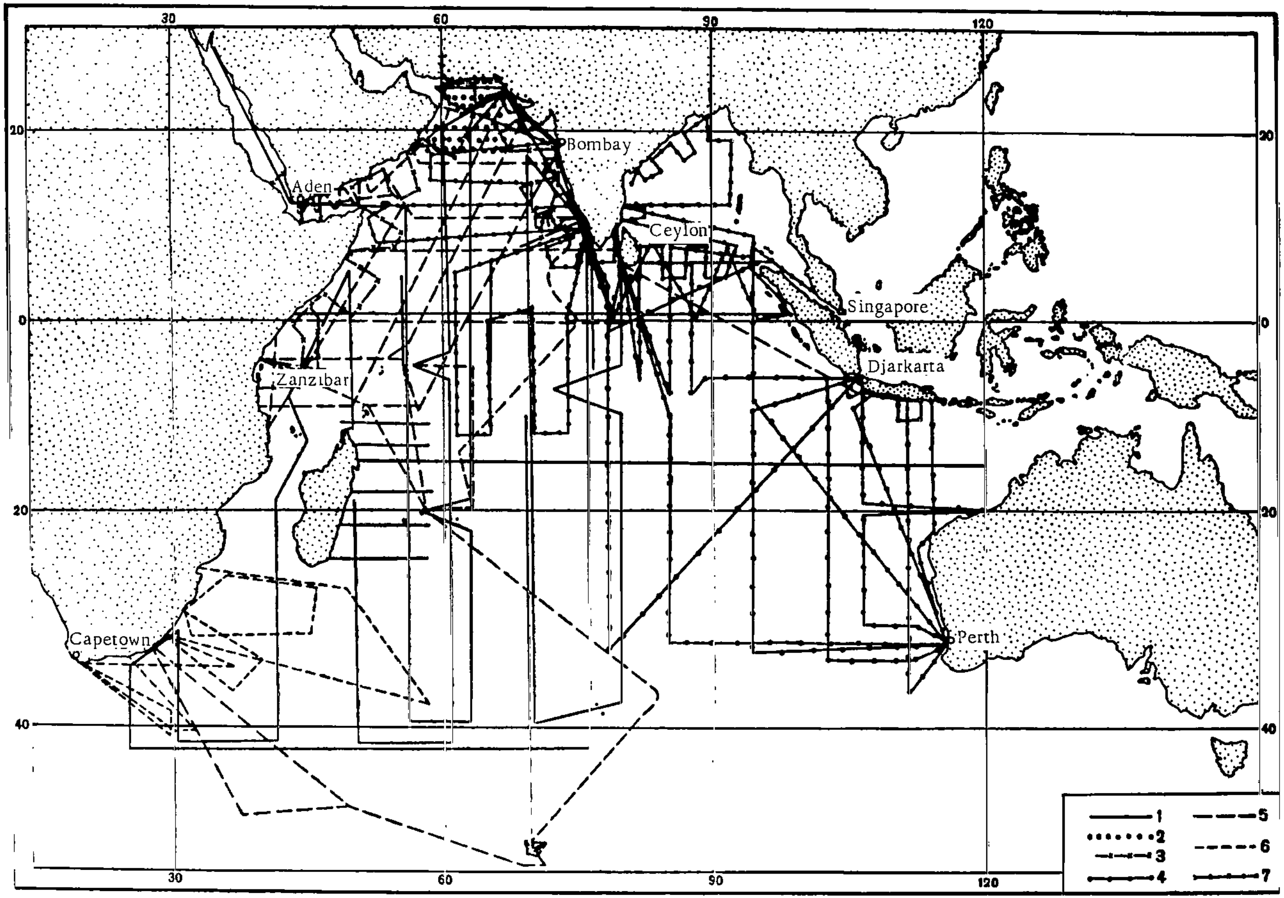


FIGURE 3. Sea routes of non-Soviet research vessels in the Indian Ocean during 1962 and 1963.
1 — U. S. A; 2 — Pakistan; 3 — Germany; 4 — Japan; 5 — England; 6 — South Africa; 7 — India.

Special time is allotted for the study of the equatorial zone and investigation of its seasonal variations (repeated voyages, also at monthly intervals).

The American program pays much attention to meteorological research and observation of ocean level. The meteorological program for the Indian Ocean is mainly confined to large-scale study of circulation. Seven new stations are planned, located at 73°E and on the equator and equipped for radio wind sounding. The program makes provision for two weather ships, and also meteorological buoys of the "Manos" type to be floated — one in the Arabian Sea and one in the Bay of Bengal. American programs also provide for aircraft observations, observations at sea-air interface, measurements of evaporation, heat and energy losses, measurements of the size of water particles, observations of radiation, etc. Observations of ocean level will, according to the American program, be made at 28 stations.

Of particular interest is the program of repeated and new geophysical studies on the Indian shelf.

An International Center for Weather Forecasting and Storm Forewarning was established in the region of the Indian Ocean at Bombay.

The English program of oceanographic research for 1962-1964 concentrates in the western part of the ocean (Figure 3). Four ships are scheduled to take part in it. Provision is made for physicochemical, geological, geophysical, hydrographic, and biological work.

During October, 1962, five Japanese oceanographic vessels launched on a quasisynoptic charting of the eastern part of the Indian Ocean. Their program provides for comprehensive research in the season of northeasterly winds.

The Soviet program will be undertaken by the expedition vessel "Vityaz'". During 1962 it operated in the season of southwesterly winds; in the season of northeasterly winds extensive comprehensive observations were made on sections with stations spaced at every 60-120 miles and with anchor buoys floated on the average every 600 miles.

The program provides for geological, geophysical, meteorological, hydrological, physical, chemical, and biological observations and sample collecting.

Meteorological observations, besides climatologic, synoptic, aerologic, and actinometric determinations, will also cover gradient measurements in the surface layer near the water. Anchor buoys with self-recording instruments will be released at various depths on 2°-5°S. latitude where previous expeditions detected an abyssal countercurrent. It is proposed to repeat hydrochemical measurements in those regions where on the previous voyages of the "Vityaz'" nitrite highs and oxygen lows (by standards of the World Ocean) were discovered, and also in regions of H_2S contamination at the intermediate depths of the Arabian Sea and the Bay of Bengal.

American scientists suggest that the material collected by the Indian Ocean expedition should be condensed to an atlas, including profiles and charts of oceanographic characteristics. According to the American scientists, the atlas should be compiled at one place, under the direction of a leading oceanographer and, possibly, in cooperation with oceanographers of several countries.

Fellows of the Institute of Oceanology AN SSSR proposed to publish a monograph, "The Indian Ocean", including an atlas of the ocean which would generalize the available data on meteorology, hydrology, physics, chemistry, water biology, and geology.

The Hydrographic Department of Great Britain started collecting data of echo sounding of the Indian Ocean during 1961 with the object of constructing a relief chart of its bottom.

Since multi-faceted and all-sided treatment and analysis of the materials of the Indian Ocean expedition will result in better assimilation of the results, it is desirable to ensure extensive and comprehensive exchange of oceanographic data on the Indian Ocean. Any country participating in the Indian Ocean expedition should be given the opportunity of generalizing and analyzing its material, including that collected prior to the IGY.

Appendix

Soviet oceanographical studies of the Indian Ocean, published up to 1963

1. Babayan, K. E. Rybolovstvo Tseilona (The Ceylonese Fishing Industry). — Moskva, Izd-vo "Rybnoe khozyaistvo." 1960.
2. Babayan, K. E. Ryby Tseilona (The Fishes of Ceylon). — Priroda, No. 10, 69-73. 1960.
3. Balashov, Yu. A. and L. M. Khitrov. Raspredelenie redkozemel'nykh elementov v vodakh Indiiskogo okeana (Distribution of Rare Earth Elements in the Indian Ocean). — Geokhimiya, No. 9, 796-806. 1961.
4. Barsukov, V. V. and Yu. E. Permitin. Ikhtiologicheskie issledovaniya (Ichthyological Research). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 7, pp. 97-104. — Leningrad, Izd-vo "Morskoi transport." 1960.
5. Bezrukov, P. L. Issledovanie donnykh osadkov severnoi chasti Indiiskogo okeana (Research on the Bottom Sediments of the Northern Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 66-71. 1961.
6. Bezrukov, P. L. Issledovaniya Indiiskogo Okeana v 33-m reise e/s "Vityaz'" (Research in the Indian Ocean on the 33rd Trip of the R/V "Vityaz'"). — Okeanologiya, 1, No. 4, 745-752. 1961.
7. Bezrukov, P. L., L. K. Zatonskii, and I. V. Sergeev. Gora Afanasiya Nikitina v Indiiskom Okeane (Afanasii Nikitin Mountain in the Indian Ocean). — Dokl. AN SSSR, 139, No. 1, 199-202. 1961.
8. Beklemishev, K. V. Issledovaniya fitoplanktona (Research on Phytoplankton). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 7, pp. 143-152. — Leningrad, Izd-vo "Morskoi transport." 1960.
9. Beklemishev, K. V. and V. S. Korotkevich. Issledovaniya zooplanktona (Research on Animal Plankton). In the book: Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na

d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty 7, pp. 105-110. — Leningrad, Izd-vo "Morskoi transport." 1960.

10. Belousov, I. M. 31-i reis e/s "Vityaz' " (31st Trip of the E/S "Vityaz'"). — Okeanologiya, 1, No. 2, 319-321. 1961.

11. Belyaev, G. M. and M. E. Vinogradov. Zoologicheskie issledovaniya v 31 m reise e/s "Vityaz'" (Zoological Research on the 31st Trip of the E/S "Vityaz'"). Zool. zh. 40, No. 2, 303-308. 1961.

12. Belyaev, G. M. and N. G. Vinogradova. Issledovaniya donnoi fauny Yavanskoi glubokovodnoi vpadiny (Research on the Fauna of the Bottom of the Java Deep-Sea Basin). — Okeanologiya, 1, No. 1, 125-132. 1961.

13. Belyaev, G. M. and N. G. Vinogradova. Kolichestvennoe raspredelenie donnoi fauny v severnoi polovine Indiiskogo okeana (Quantitative Distribution of Bottom Fauna in the Northern Half of the Indian Ocean). — Dokl. AN SSSR, 138, No. 5, 1191. 1961.

14. Bogorov, V. G. and M. E. Vinogradov. Nekotorye cherty raspredelenie biomassy planktona v poverkhnostnykh vodakh Indiiskogo okeana zimoi 1959/60 g (Some Characteristics of the Plankton Biomass Distribution in the Surface Waters of the Indian Ocean in the Winter of 1959/60). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 66-71. 1961.

15. Bogorov, V. G. and T. S. Rass. O produktivnosti i perspektivakh rybolovstva v vodakh Indiiskogo okeana (The Productivity and Prospects of the Fishing Industry in the Indian Ocean). — Okeanologiya, 1, No. 1, pp. 107-109. 1961.

16. Bogoyavlenskii, A. N. Gidrokhimicheskie issledovaniya (Hydrochemical Research). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 159-172. — Leningrad, Izd-vo "Morskoi transport." 1960.

17. Bordovskii, O. K. K khimii donnykh otlozhenii Indiiskogo okeana (On the Chemistry of the Sediments at the Bottom of the Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanografiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanography)). — Izd-vo AN SSSR, pp. 91-99. 1961.

18. Bugaev, V. A. Klimaticheskie zony Vostochnoi Antarktidy i Yuzhnogo okeana (Climatic Zones of Eastern Antarctica and the Southern Ocean). Meteorologiya i gidrologiya, No. 3, pp. 1-10. 1960.

19. Vinogradov, M. E. and N. M. Voronina. Vliyanie defitsita kisloroda na raspredelenie planktona v Araviiskom more (The Effect of the Oxygen Deficiency on Plankton Distribution in the Arabian Sea). — Okeanologiya, 1, No. 4, 670-678. 1961.

20. Vinogradov, M. E. and N. M. Voronina. Raspredelenie nekotorykh massovykh vidov kopepod v Indiiskom okeane (Distribution of Several Bulk Forms of Copepods in the Indian Ocean). — Dokl. AN SSSR, 140, No. 1, pp. 219-222. 1961.

21. Vinogradov, M.E. and N.M. Voronina. Raspredelenie zooplanktona severnoi chasti Indiiskogo okeana (Distribution of Animal Plankton in the Northern Part of the Indian Ocean). — Tr. In-ta okeanologii AN SSSR, 58, pp. 80-113. 1962.
22. Vinogradov, M.E. and N.M. Voronina. The Distribution of Different Groups of Plankton in Accordance with their Trophic Level in the Indian Equatorial Current Area. — Rapp. et Proc. — Verb. Cons. Internat. Explor. de la Mer, 153. 1962.
23. Vinogradov, M.E., Voronina, N.M., and I.N. Sukhanova. Gorizontal'noe raspredelenie tropicheskogo planktona i ego svyaz' s nekotorymi osobennostyami struktury vod otkrytykh raionov okeana (Horizontal Distribution of Tropical Plankton and its Relation to Several Structural Features of the Waters of Open Areas of the Ocean). — Okeanologiya, 1, No. 2, pp. 237-240. 1961.
24. Vinogradova, N.G. K voprosu o geograficheskom rasprostranenii glubokovodnoi donnoi fauny Antarktidy (On the Geographical Diffusion of the Deep-Sea-Bottom Fauna of Antarctica). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 2, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 2). — Moskva, Izd-vo AN SSSR, pp. 108-112. 1960.
25. Voronina, N.M. O pripoverkhnostnom zooplanktone Indiiskogo okeana (Animal Plankton of the Surface of the Indian Ocean). Tr. Instituta okeanologii AN SSSR 58, pp. 67-79. 1962.
26. Voronina, N.M. O raspredelenii makroplanktona v severnoi polovine Indiiskogo okeana (Distribution of Macroplankton in the Northern Half of the Indian Ocean). — Okeanologiya, 2, No. 1, pp. 118-125. 1962.
27. Gidrologicheskie, gidrokhimicheskie, geologicheskie i biologicheskie issledovaniya (Hydrological, Hydrochemical, Geological, and Biological Research). R/v "Ob'" 1955-1956. Sb. materialov (Collection of Data). — Leningrad, Gidrometeoizdat. 1958.
28. Gorbunova, Z.N. Vysokodispersnye mineraly v osadkakh Indiiskogo okeana (Highly Dispersed Minerals in the Sediments of the Indian Ocean). — Dokl. AN SSSR, 134, No. 4, 935-938. 1960.
29. Gorbunova, Z.N. Glinistye i soputstvuyushchie im mineraly v donnykh osadkakh Indiiskogo okeana (Clayey and Associated Minerals in the Sediments of the Indian Ocean Bottom). — Tr. Instituta okeanologii AN SSSR, 61, pp. 93-103. 1961.
30. Gorbunova, Z.N. Sostav glinistykh mineralov v raznykh gorizontakh osadkov Indiiskogo okeana (Composition of Clayey Minerals in Various Sediment Beds of the Indian Ocean). — Dokl. AN SSSR, 134, No. 5, 1201-1203. 1960.
31. Gordeev, Yu.A. Gidrograficheskie raboty (Hydrographic Studies). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 144-153. — Leningrad, Izd-vo "Morskoi transport." 1959.
32. Dannye po rel'efu dna, poluchennye v pervom antarkticheskom reise d/e "Ob'" (Data on the Bottom Relief, Obtained During the First Antarctic Expedition of the R/V "Ob'"). Moskva. 1960.
33. Zhivago, A.V. Geomorfologicheskie issledovaniya (Geomorphological Research). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957.

Nauchnye rezul'taty, 7, pp. 44-72. — Leningrad, Izd-vo "Morskoi transport." 1960.
34. Zhivago, A. V. Tektonika i geomorfologiya dna yuzhnoi chasti Indiiskogo okeana (Tectonics and Geomorphology of the Southern Part of the Indian Ocean). In the book, Morskaya geologiya (Marine Geology). — Izd-vo AN SSSR, pp. 18-34. 1960. (International Geological Congress, 21st Session).
35. Zhivago, A. V. and A. P. Lisitsyn. V glubinakh Antarkticheskikh morei (In the Depths of the Antarctic Seas). — Nauka i zhizn', No. 12, 21. 1956.
36. Zhivago, A. V. and A. P. Lisitsyn. Novye dannye o rel'efe dna i osadkakh morei Vostochnoi Antarktiki (New Data on the Bottom Relief and Sea Sediments in the Eastern Antarctic). — Izv. AN SSSR, seriya geograficheskaya, No. 1, 19-35. 1957.
37. Zhuze, A. P., G. S. Koroleva, and G. A. Nagaeva. Diatomovye vodorosli v poverkhnostnom sloe donnykh osakov Indiiskogo sektora Antarktiki (Diatoms in the Surface Layer of the Bottom Sediments in the Indian Sector of the Antarctic). — Tr. Instituta okeanologii AN SSSR, 61, pp. 19-92. 1962.
38. Zernova, V. V. Kolichestvennoe respredelenie fitoplanktona v severnoi chasti Indiskogo okeana (Qualitative Distribution of Phytoplankton in the Northern Part of the Indian Ocean). — Tr. Instituta okeanologii AN SSSR, 58, pp. 45-53. 1962.
39. Ivanenkov, V. N. and F. A. Gubin. Vodnye massy i gidrokhimiya zapadnoi i yuzhnoi chastei Indiiskogo okeana (Water Masses and Hydrochemistry of the Western and Southern Parts of the Indian Ocean). — Tr. Morskogo gidrofiz. instituta, 22, pp. 33-115. 1960.
40. Ivanenkov, V. N. and A. G. Rozanov. Serovodorodnoe zarazhenie promezhutochnykh sloev Araviiskogo morya i Bengal'skogo zaliba (Hydrogen Sulfide Contamination of Intermediate Layers of the Arabian Sea and of the Bay of Bengal). — Okeanologiya, 1, No. 3, pp. 443-459. 1961.
41. Ivanov-Frantskevich, G. N. O nekotorykh osobennostyakh gidrologicheskoi struktury i vodnykh massakh Indiiskogo okeana (Some Features of the Hydrologic Structure and the Water Masses of the Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 7-17. 1961.
42. Ivanov, Yu. A. and N. S. Smetanina. Geostrficheskie techeniya Indiiskogo sektora Antarktiki (Geostrophic Currents in the Indian Sector of the Antarctic). — In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 2). — Moskva, Izd-vo AN SSSR, pp. 100-103. 1960.
43. Ivashin, M. V. O raspredelenii stad gorbatogo kita v Yuzhnom polusharii (The Distribution of Herds of Humpback Whales in the Southern Hemisphere). — VNIRO Information Bulletin, No. 7, pp. 3-11. 1959.
44. Kabanova, Yu. G. Pervichnaya produktsiya i soderzhanie biogennykh elementov v vodakh Indiiskogo okeana (Primary Production and Content of Organic Substances in the Waters of the Indian Ocean). In

the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 72-75. 1961.

45. Kovylin, V. M. Novye dannye o moshchnosti donnykh otlozhenii Indiiskogo okeana (New Data on Sediment Thickness on the Indian Ocean Bottom). — Dokl. AN SSSR, 136, No. 4, pp. 924-926. 1961.

46. Kovylin, V. M. Rezul'taty seismoakusticheskikh issledovanii k vostoku ot Afriki v raione ostrova Zanzibar i v tsentral'noi chasti Indiiskogo okeana (Results of Seismoacoustic Research East of Africa near Zanzibar Island in the Central Part of the Indian Ocean). — Okeanologiya, 1, No. 3, pp. 466-472. 1961.

47. Kovylin, V. M. Seismoakuticheskie issledovaniya v okeane metodom otrazhennykh voln s mnogokanal'noi priemoi sistemoi (Seismoacoustic Research in the Ocean by the Method of Reflected Waves with a Multichannel Receiving System). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research, Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 100-108. 1961.

48. Kozlova, O. G. Vidovoi sostav diatomovykh vodoroslei v vodakh Indiiskogo sektora Antarktiki (Composition by Species of Diatoms in the Waters of the Indian Sector of the Antarctic). — Tr. Instituta okeanologii AN SSSR, 61, pp. 3-18. 1962.

49. Kozlova, O. G. Kolichestvennoe soderzhanie diatomei v vodakh Indiiskogo sektora Antarktiki (Diatom Content of the Waters of the Indian Sector of the Antarctic). — Dokl. AN SSSR, 133, No. 1, pp. 207-210. 1961.

50. Korotkevich, V. S. Novyi vid nemertin i ego polozhenie v sisteme (A New Form of Nemertine and its System Position). — Zool. zh., 40, No. 9, pp. 1416-1420. 1961.

51. Korotkevich, V. S. O novom rode pelagicheskikh nemertin iz Antarktiki (A New Type of Abyssal (Deep-Sea) Nemertine from the Antarctic). — Zool. zh., 39, No. 6, pp. 838-841. 1960.

52. Kort, V. G. Issledovaniya tret'ei morskoi antarkticheskoi ekspeditsii AN SSSR (Research of the Third SAE). — Tr. Okeanografichiskoi komissii AN SSSR, 10, No. 1, pp. 127-136. 1961.

53. Kriss, A. E., S. S. Abyzov, M. N. Lebedev, I. E. Mishustina, and N. M. Mitskevich. Geograficheskie zakonomernosti raspredelenie mikrobnogo naceleniya (geterotrofov) v Mirovom okeane (Geographical Distribution Laws of the Microbe Population (Heterotrophs) in the World Ocean). — Izv. AN SSSR, geographical series, No. 5, pp. 34-41. 1960.

54. Kryndin, A. N. Pervyi reis e/s "Yu. M. Shokal'skii" i ego nauchnye rezul'taty (First Voyage of the E/S "Yu. M. Shokal'skii" and its Scientific Results). — Okeanologiya, 1, No 3, pp. 543-548. 1961.

55. Kutyurin, V. M. Opredelenie soderzhaniya khlorofilla v morskoi vode i spektral'nyi analiz pigmentov fitoplanktona (Determination of the Chlorophyll Content of Sea Water and Spectral Analysis of the Pigments of Phytoplankton). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 173-175. — Leningrad, Izd-vo "Morskoi transport." 1959.

56. L e v e n s h t e i n, R. Ya. Novye dannye o mnogoshchetinkovykh chervyakh (Polychaeta) Yavanskoi vpadiny (New Data on the Polychaeta of the Java Depression). — Okeanologiya, 1, No. 1, pp. 136-139. 1961.
57. L i s i t s y n, A. P. Issledovaniya po geologii dna priantarkticheskikh morei (Geological Research on the Bottom of the Antarctic Seas), In the book, Sovetskie issledovaniya v Antarktike (Soviet Research in the Antarctic). — Moskva, Izdatel'stvo "Znanie," p. 28. 1957.
58. L i s i t s y n, A. P. Morskie geologicheskie issledovaniya (Marine Geological Research). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 7, pp. 7-43. — Leningrad, Izd-vo "Morskoi transport." 1960.
59. L i s i t s y n, A. P. Novye dannye o raspredelenii i sostave vzveshennykh veshchestv v moryakh i okeanakh v svyazi s voprosami geologii (New Data on the Distribution and Composition of Suspended Matter in the Seas and Oceans as Related to Geological Questions). — Dokl. AN SSSR, 126, No. 4, pp. 863-866. 1961.
60. L i s i t s y n, A. P. Osadkoobrazovanie v yukhnykh chastyakh Tikhogo i Indiiskogo okeanov (Formation of Sediments in the Southern Parts of the Pacific and Indian Oceans). In the book, Morskaya geologiya. — Moskva,, Izdatel'stvo AN SSSR, pp. 69-87. 1960 (International Geological Congress, 21st Session).
61. L i s i t s y n, A. P. Raspredelenie i sostav vzvesi v vodakh Indiiskogo okeana (Distribution and Composition of Suspended Matter in the Indian Ocean). In the book, Okeanologicheskie issledovaniya, Sb. statei No. 2. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 2. Section X of the IGY Program (Oceanology)). — Moskva, Izdatel'stvo AN SSSR, pp. 71-85. 1960.
62. L i s i t s y n, A. P. and A. V. Z h i v a g o. Rel'ef dna i osadki yuzhnoi chasti Indiiskogo okeana (Bottom Relief and Sediments of the Southern Part of the Indian Ocean). — Izv. AN SSSR, seriya geograficheskaya, Nos. 2 and 3. 1958.
63. L i s i t s y n, A. P. and A. V. Z h i v a g o. Sovremennye metody izucheniya geomorfologii i osadkov dna morei Antarktiki (Modern Methods for Study of the Sea-Bottom Geomogphology and Sediments of the Antarctic Seas). — Izv. AN SSSR, seriya geograficheskaya, No. 6, pp. 88-97. 1958.
64. L u k ' y a n o v, V. V. and L. K. M o i s e e v. Raspredelenie temperatury vody v severnoi chasti Indiiskogo okeana (Water Temperature Distribution in the Northern Part of the Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 31-43. 1961.
65. M a k s i m o v, I. V. Vtoraya morskaya antarkticheskaya ekspeditsiya AN SSSR (Second Marine Antarctic Expedition of the AN SSSR). — Problemy Arktiki, No. 5, pp. 133-136. 1958.
66. M a k s i m o v, I. V. Vtoraya morskaya antarkticheskaya ekspeditsiya (The Second Marine Antarctic Expedition). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 7-18. — Leningrad, Izd-vo "Morskoi transport." 1959.

67. M a k s i m o v , I. V. Yuzhnyi okean i Antarktika (The Southern Ocean and the Antarctic). — Okeanologiya, 1, No. 4, pp. 577-591. 1961.
68. M a m a e v , O. I. O polozhenii nulevoi poverkhnosti v Indiiskom okeane (The Position of the Datum Level in the Indian Ocean). In the book, Voprosy okeanologii. Sb. statei (Questions of Oceanology. Collection of Articles). — Moskva, Izdatel'stvo Moskovskogo universiteta, pp. 121-126. 1960.
69. M a n , I. A. Vtoroe plavanie d/e "Ob'" (Second Voyage of the R/V "Ob'"). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 19-26. — Leningrad, Izd-vo "Morskoi transport." 1959.
70. M i k h a i l o v , S. V. Resursy Mirovogo okeana (Resources of the World Ocean). — Priroda, No. 9, pp. 32-40. 1961.
71. M o k i e v s k a y a , V. V. Hekotorye gidrokhimicheskie cherty severnoi chasti Indiiskogo okeana (Some Hydrochemical Features of the Northern Part of the Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 62-65. 1961.
72. M o r o z o v , A. P. Nablyudeniya nad morskim volneniem (Observations "Ob'"). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/d "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 138-143. — Leningrad, Izd-vo "Morskoi transport." 1959.
73. M o r o s h k i n , K. V. Gidrologicheskie issledovaniya (Hydrological Research). In the book, The Soviet Antarctic Expedition. Second Marine Expedition of the R/V "Ob'" 1956-1957. Obshchee opisanie i nauchnye rezul'taty (General Description and Scientific Results), 5, pp. 106-123. — Leningrad, Izd-vo "Morskoi transport." 1959.
74. M o r o s h k i n , K. V. Izmereniya techenii v yugo-zapadnoi chasti Indiiskogo okeana elektromagnitnym metodom (Electromagnetic Measurement of Currents in the South-Western Part of the Indian Ocean). — Informatsionnyi byulleten' SAE, No. 7, pp 22-25. 1959.
75. M o r o s k h i n , K. V. and M. A. B o g d a n o v . Rezul'taty primeneniya elektromagnitnogo izmeritelya techenii v Indiiskom okeane i v yuzhnoi chasti Tikhogo okeana (Results of the Application of Electromagnetic Current Measurement in the Indian Ocean and in the South Pacific). of Sea Swells). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 5, pp. 124-137. — Leningrad, Izd-vo "Morskoi transport." 1959.
76. M u r o m t s e v , A. M. K gidrologii Krasnogo morya (A Contribution to the Hydrology of the Red Sea). — Dokl. AN SSSR, 134, No. 6, pp. 1443-1446. 1960.
77. M u r o m t s e v , A. M. Naibol'shie glubiny yuzhnogo polushariya (Maximum Depths in the Southern Hemisphere). — "Priroda," No. 5, pp. 90-91. 1956.
78. M u r o m t s e v , A. M. Novye karty raspredeleniya solenosti na poverkhnosti Indiiskogo okeana (New Maps of the Salinity Distribution

on the Surface of the Indian Ocean). — Meteorologiya i gidrologiya, No. 11, pp. 35-37. 1958.

79. Muromtsev, A. M. Okeanograficheskaya izuchennost' Indiiskogo okeana (Possibilities for Oceanographical Study of the Indian Ocean). — Meteorologiya i gidrologiya, No. 6, pp. 14-18. 1958.

80. Muromtsev, A. M. Osnovnye cherty gidrologii Indiiskogo okeana (po dannym nablyudenii c 1772 po 1957 g.) (Basic Features of the Hydrology of the Indian Ocean (Based on Data Collected from 1772 to 1957)). — Leningrad, Gidrometeoizdat. 1959.

81. Muromtsev, A. M. Plotnost' vody na poverkhnosti Indiiskogo okeana (Density of the Surface Water of the Indian Ocean). — Dokl. AN SSSR, 123, No. 6, pp. 1014-1017. 1958.

82. Muromtsev, A. M. Tipy godovogo khoda temperatury vody v poverkhnostnom sloe okeana (Kinds of Annual Water Temperature Cycle in the Surface Layer of the Ocean). — Dokl. AN SSSR, 196, No. 5, p. 776. 1957.

83. Neprochnov, Yu. P. Moshchnost' osadkov kotloviny Araviiskogo morya (Sediment Thickness of the Arabian Sea Basin). — Dokl. AN SSSR, 139, No. 1, pp. 177-179. 1961.

84. Neprochnov, Yu. P. Novye dannye o stroenii zemnoi kory pod dnom Indiiskogo okeana (New Data on Crustal Structure Beneath the Bottom of the Indian Ocean). — Dokl. AN SSSR, 144, No. 2, pp. 442-444. 1962.

85. Nefed'ev, V. P. Glubinnye vodnye massy morei Indonezii (Abyssal Water Masses of the Indonesian Seas). — Okeanologiya, 1, No. 1, pp. 36-44. 1961.

86. Nefed'ev V. P. Sovremennaya izuchennost' morei Indonezii (Existing Possibilities for Study of the Indonesian Seas). — Okeanologiya, 1, No. 3, pp. 556-563. 1961.

87. Ovchinnikov, I. M. Tsirkulyatsiya vod severnoi chasti Indiiskogo okeana v period zimnego mussona (Water Circulation in the Northern Indian Ocean at the Period of the Winter Monsoon). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 18-24. 1961.

88. Orlov, V. P. Ob oshibkakh Mirovykh kart napryazhennosti geomagnitnogo polya T v yuzhnoi chasti Indiiskogo okeana (Errors in the Universal Maps of the Geomagnetic Field Intensity T in the Southern Indian Ocean). — Izv. AN SSSR, seriya geograficheskaya, No. 12, pp. 1870-1872. 1959.

89. Pavlov, V. M. Opticheskie kharakteristiki osnovnykh vodnykh mass severnoi chasti Indiiskogo okeana (Optical Characteristics of the Major Water Masses in the Northern Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4. X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 44-49. 1961.

90. Panov, D. G. Proiskhozhdenie materikov i okeanov (Origin of the Continents and Oceans). — Moskva, Geografgiz. 1961.

91. Panteleev, N. A. Issledovaniya turbulentnosti v poverkhnostom sloe vod Antarkticheskogo sektora Indiiskogo i Tikhogo okeanov (Research on Turbulence in the Surface Layer of the Antarctic Sector

of the Indian and Pacific Oceans). — Tr. Okeanograficheskoi komissii AN SSSR, 10, No. 1, pp. 133-140. 1960.

92. Parin, N.V. K poznaniyu fauny letuchikh ryb (semeistvo Exocoetidae) Tikhogo i Indiiskogo okeanov (A Contribution to Knowledge of the Flying Fish (family of Exocoetidae) of the Pacific and Indian Oceans).— Tr. Instituta okeanologii AN SSSR, 43, pp. 40-91. 1961.

93. Parin, N. V. Oxyporamphus meristocystis (Pisces oxyporamphidea)— novyi vid letuchego poluryla iz vod Indo-Malaiskogo arkhipelaga (Oxyporamphus meristocystis (Pisces oxyporamphidae) — A New Type of Flying Amphibian from the Waters of the Indo-Malay Archipelago).— Voprosy ikhtiologii, 1, No. 3(20), pp. 391-394. 1961.

94. Parin, N. V. and F. A. Pasternak. Zoologicheskie issledovaniya v 33-m reise e/s "Vityaz'" (Zoological Research on the 33rd Voyage of the E/S "Vityaz'"). — Zool. zh. 41, No. 1, p. 155. 1962.

95. Pasternak, F. A. Pennatulyarii (Octocorallia) i antipatarii (Hexocorallia), sobrannye Sovetskoi kompleksnoi antarkticheskoi ekspeditsiei v 1955-1958 gg. (Octocorallia and Hexocorallia Collected by the SAE in 1955-1958). — Tr. Instituta okeanologii AN SSSR, 56, pp. 217-230. 1961.

96. Pasternak, F. A. and A. V. Gusev. Bentonicheskie issledovaniya. (Benthonic Research). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Vtoraya morskaya ekspeditsiya na d/e "Ob'" 1956-1957 gg. Nauchnye rezul'taty, 7, pp. 126-142. — Leningrad, Izd-vo "Morskoi transport." 1960.

97. Ponomareva, L. A. and A. G. Naumov. Raspredelenie biomassy zooplanktona v vodakh Araviiskogo morya i Bengal'skogo zaliva v period smeny mussonov (Distribution of the Biomass of Animal Plankton in the Waters of the Arabian Sea and the Bay of Bengal at the Period of the Monsoon Shift). — Dokl. AN SSSR, 142, No. 2, pp. 449-452. 1962.

98. Ponomareva,. L. A., A. G. Naumov, and V. V. Zernova. Sostav pishchi nekotorykh vidov evfauziid v Indiiskom okeane (Diet of Some Types of Euphausiids in the Indian Ocean). — Tr. okeanologii AN SSSR, 58, pp. 163-166. 1862.

99. Rass, T. S. Novaya glubokovodnaya ryba (Prososcopa stibia Rass., gen. n, sp. n.) iz Indiiskogo okeana (A New Deep-Water Fish (Prososcopa stibia Rass., gen. n, sp. n.) from the Indian Ocean). — Zool. zh., 40, No. 12, pp. 1858-1861. 1961.

100. Romanov, Yu. A. Ob usloviyakh primeneniya dinamicheskogo metoda v ekvatorial'noi chasti Indiiskogo okeana (Conditions for the Application of a Dynamic Method in the Equatorial Region of the Indian Ocean). In the book, Okeanologicheskie issledovaniya. Sb. statei No. 4, X razdel programmy MGG (okeanologiya) (Oceanological Research. Collection of Articles No. 4. Section X of the IGY Program (Oceanology)). — Izd-vo AN SSSR, pp. 25-30. 1961.

101. Rudyakov, Yu. A. Novyi vid (Ostracoda) iz semeistva (Cytchcridae) s ul'traabissal'nykh glubin Yavanskoi vpadiny (A New Species (Ostracoda) of the Family Cytchcridae from the Ultraabyssal Regions of the Java Depression). — Tr. Instituta okeanologii AN SSSR, 51, pp. 116-120. 1961.

102. Saidova, Kh. M. Kolichestvennoe raspredelenie donnykh foraminifer v Antarktike (Numerical Distribution of Benthonic Foraminifers in

the Antarctic). — Dokl. AN SSSR, 139, No. 4, pp. 967-969. 1961.

103. Smetanina, N.S. Teplosoderzhanie antarkticheskikh vod (Thermal Content of Antarctic Waters). — Okeanologiya, 1, No. 3, pp. 412-417, 1961.

104. Starik, I.E. and A.P. Zharkov. Skorost' osadkonakopleniya v Indiiskom okeane po dannym radiouglerodnogo metoda (Rapidity of Sediment Accumulation in the Indian Ocean According to Radioactive Carbon Methods). — Dokl. AN SSSR, 136, No. 1, pp. 203-205. 1961.

105. Stepanov, V.N. Godovoi khod temperatury vod na poverkhnosti Mirovogo okeana i gidrologicheskie sezony (Annual Temperature Cycle of the Surface Waters of the World Ocean and Hydrological Seasons). — Okeanologiya, 1, No. 3, pp. 399-406. 1961.

106. Sukhanova, I.N. O vidovom sostave i raspredelenii fitoplanktona severnoi chasti Indiiskogo okeana (The Observable Composition and Distribution of Phytoplankton in the Northern Indian Ocean). — Tr. Instituta okeanologii AN SSSR, 58, pp. 27-39. 1962.

107. Sukhanova, I.N. O tropicheskom fitoplanktone Indiiskogo okeana (The Tropical Phytoplankton of the Indian Ocean). — Dokl. AN SSSR, 142, No. 5, pp. 1162-1164. 1962.

108. Sysoev, N.N., I.E. Mikhal'tsev, G.B. Udintsev, I.B. Andreev, A.P. Lisitsyn, and Yu.P. Neprochnov. Rezul'taty seismoakusticheskikh issledovanii stroeniya zemnoi kory v moryakh i okeane (Results of Seismoacoustic Research on Crustal Structure in the Seas and Oceans). In the book, Morskaya geologiya. — Moskva, Izdatel'stvo AN SSSR, pp. 35-44. 1960. (International Geological Congress, 21st Session).

109. Tauber, G.M. Sinopticheskie usloviya Indiiskogo sektora Antarktiki (Synoptic Conditions in the Indian Sector of the Antarctic). In the book, Sovetskaya antarkticheskaya ekspeditsiya. Pervaya kontinental'naya ekspeditsiya 1955-1957 gg. (The Soviet Antarctic Expedition. First Continental Expedition 1955-1957). — Leningrad, Izdatel'stvo "Morskoi transport," 2, pp. 46-48. 1959.

110. Filatova, Z.A. Nekotorye novye dannye o dvystvorchatykh mollyuskakh Yavanskoi vpadiny (Some New Data on Bivalve Molluscs in the Java Depression). — Okeanologiya, 1, No. 1, pp. 133-135. 1961.

111. Khromov, S.P. Nablyudeniya nad oblakami i osadkami v tropicheskikh okeanakh (Observations of Clouds and Sediments in the Tropical Oceans). — Izv. Vsesoyuznogo geograficheskogo obshchestva, No. 3, pp. 199-210. 1961.

112. Shesterikov, N.P. Vliyanie teplozapasa vod na sroki zamerzaniya morya Deivisa i prilegayushchei chasti Indiiskogo okeana (The Influence of the Thermal Supply of the Water upon the Periods of Freezing in the Davis Sea and the Adjacent Part of the Indian Ocean). — Informationnyi Byulleten' SAE, No. 19, pp. 35-38. 1960.

V. N. Stepanov

RESEARCH ON THE WORLD OCEAN

The American government has allocated a sum in excess of 650 million dollars for realization of the World Ocean research program planned for the decade 1960-1970. The U.S.A. program /1/ envisages rapid and comprehensive development of oceanological research for study of the nature and natural resources of the World Ocean, radioactivity in the oceans collection of data necessary to evaluate the influence of the hydrosphere on the climate, possibilities of controlling it, etc. Systematic surveys of all the waters of the World Ocean are proposed, and the program incorporates: (a) the construction of 70 ships (of 500, 1200, or 2200 tons) in order to increase the number of vessels in the research fleet to 85 by the end of the decade, taking into account replacement of part of the fleet; (b) the creation of new engineering techniques (for bathyscapes, drifting and anchor buoys, some with crews, special submarine boats, machinery for drilling in the ocean floor at great depths, expeditionary and laboratory equipment, calculating machines, etc.); (c) special measures to train personnel and provide material support for scientists; (d) the construction of shore bases for expeditionary research, data processing and storage; (d) the establishment of marine research centers.

The fundamental plan — systematic research on the World Ocean — envisages comprehensive oceanographic surveys and construction of many stations at specific points. The detail of the oceanographic surveys is made the basis for a division of the World Ocean into regions for three types of detailed research: synoptic and oceanographic surveys, and general (exploratory) research. The first region is largely confined to the northern Atlantic, and extends from 15°S. lat. to the northern boundaries of Baffin Bay, the Greenland Sea, and most of the Barents Sea, the open part of the Indian Ocean, north of 5°S. lat., and the entire part of the Pacific Ocean north of 20°N. lat., and includes the Chuckchee Sea and the southern part of the Beaufort Sea. Synoptic surveys are planned for the Gulfstream and Curaçao currents, as well as in the north-eastern Pacific. General research is planned for the entire remaining part of the World Ocean. The time needed to complete all this oceanographic research was calculated from the fact that an expedition vessel averaging 10 knots over a 24-hour period must be directly employed in surveys 240 days per year, or 20 days per month.

A single oceanographic survey, with distances of 180 nautical miles between stations, will be made in the regions designated for general research. Only 11.5 ship-years are needed to complete this research, so that 11 or 12 vessels could finish it within one year.

Two oceanographic surveys (winter and summer), with distances of 60 miles between stations, will be made in the regions designated for detailed research. Altogether 45 ship-years will be needed. When the U. S. A. research fleet reaches 85 vessels, American scientists will be able to survey the entire World Ocean independently in the course of a single year, without having to cooperate with other countries, since the survey, according to their calculations, will require only 56 ship-years.

In the regions for which synoptic surveys were planned, simultaneous research by a large number of vessels four times a year — in months characterizing the four seasons — are projected. The research which will be conducted on a special dense network of stations, will occupy 30 days, and the surveys will be repeated in subsequent years.

Another important aspect of the oceanographic research planned by the U. S. A. is the construction of stations at 65 points, of which 20 are in the Atlantic Ocean, 14 in the Indian Ocean, and 31 in the Pacific. The stations, most of which were between 50°N. lat. and 40°-50°S. lat., were so distributed as to give the characteristics of principal currents and to give an idea of the interzonal water exchange, for which some of them constitute meridional sections of the oceans.

The program also incorporates incidental oceanographic research in the World Ocean, for which it is proposed to attract the vessels of all interested governments, as well as ships which will carry out special oceanographic surveys. En route, without stopping, the ships will perform echosounding gravimetric, geomagnetic, and meteorological observations, determine physical and chemical surface parameters, and do biological research. All of the World Ocean has been divided into three types of regions, according to the frequency with which observations are made. The amount of time and the number of ships needed to do the research in each region have been calculated.

The American plan for oceanographic research is of particular interest as one possible means for wide development of research in the World Ocean and for quantitative assessment of the time and means necessary for its accomplishment. The plans of the U. S. A. have been discussed here in greater detail than similar projects of other countries, since a good deal has already been written about them. Very little information is available about the plans of other countries involved in oceanographic research, but it can be said that they all envisage comparatively small programs. Some countries are planning combined operations in certain regions. The most extensive international research will take place in the Indian Ocean, which has been least studied, between 1962 and 1964, with the participation of the Soviet Union.

The American World Ocean research program has been proposed to the International (lit. Intergovernment) Commission on Oceanography as an international project, but the Soviet Union has proposed a different plan, based on the wide use of automatic recorders mounted on buoys 30 to 45 days apart in the northern Atlantic and Pacific Oceans. The study of these is of first importance. The Soviet plan also incorporates special research in the region of hydrologic fronts, comprehensive observations on standard sections, monthly stations performed from the participating vessels, etc. Repetition of these investigations in different seasons over several years could yield very valuable data. It must be assumed that the Commission's choice between these plans will fall upon the one best employing the united efforts and resources of the interested governments.

Fulfillment of these programs will add considerable depth to our concept of the nature and resources of the oceans. They will provide new data needed (1) to map more precisely the ocean floor and its sediments, on the basis of modern systematic measurement, to form an idea of the thickness and character of the deposits on the ocean floor, and of the geological structure and history of the World Ocean; (2) to obtain detailed information about the distribution of plant and animal organisms, biological productivity, and fishery resources; (3) to determine the amount of chemical elements in solution in sea water and their distribution in the World Ocean; (4) to study the water masses of the World Ocean and their dynamics, to which biological, chemical, and geological processes are related, and to study the physical properties and structure of sea water. If the international plan is based on the principle proposed by the Soviet Union, one can also count on obtaining extremely valuable data needed for study of the variability of hydrometeorological processes. The data obtained will be applicable to the development of plans for detailed and specialized research in individual regions of the World Ocean, and will have long-term application to the efficient utilization of natural resources.

Even very detailed surveys of the World Ocean, however, several times repeated, do not obviate the necessity of expeditions (consisting of a single vessel or several) to tackle specialized problems of physics, chemistry, geology, and biology. This will require new types of surface and underwater ships capable of carrying out various investigations at various depths and on the ocean floor. It will be necessary to design and build entirely new equipment for the collection of biological specimens, geological samples, and water samples, and most important, for their immediate rapid processing on board the ships, often without interrupting their passage.

Completely new research plans and facilities are required to deal with another most important problem — the study of the variability of hydrometeorological conditions and quantitative evaluation of fundamental hydrometeorological processes. The elaboration of this question cannot be envisaged without research to determine the laws governing variations (both seasonal and long term) in hydrometeorological conditions over the entire World Ocean and to provide the data necessary for a precise quantitative evaluation of the matter-energy cycle.*

Experience shows that repeated observations in specific regions, even though they sometimes appear to be thoroughly representative, are still insufficient for an understanding of the general laws which govern variation of hydrometeorological conditions over the entire World Ocean. Particular reference is made to standard hydrological sections and observations repeated at "roadstead points." Despite all the efforts made to use the "Kol'sk section" data (of which a tremendous amount was accumulated over the course of more than 60 years) to predict the ice regime, no reliable relationship could be established. Neither were the efforts of Japanese scientists to apply their data from standard sections to determination of the laws governing changes of hydrologic conditions in the Sea of Japan crowned with success.

Standard sections, hydrologic stations, and "weather ships" give good results only when applied to the entire area of study. However, constant repetition of oceanographic surveys over the entire World Ocean, and the

* This problem is discussed in somewhat greater detail in papers /2-4/.

use of "weather ships" in the required numbers is unfeasible, and moreover, unprofitable.

The problem of natural change and transformation can be solved only by means of the synchronized observations constantly repeated over the entire world ocean, which are needed to reveal the laws governing the variation of hydrometeorological conditions. It seems best to use automatic oceanological stations (AOS) for this purpose /1/.* These are buoys with attached automatic recorders at distances corresponding to the depths at which currents and water temperature and salinity must be measured. Such observations must first of all be made in the upper layer of some 300-500 m, within which considerable seasonal changes of hydrological conditions occur. Only in specific regions, for the most part where there are strong currents, would it be necessary to record the desired parameters at great depth. An automatic radiometeorological station (ARMS), and perhaps a wave recorder, would have to be installed inside the buoy.

A telemetric system would have to be used to transmit the results of the measurements at fixed intervals. Automatic oceanological stations can evidently be of two types: (1) for installation at specific points, and (2) drifting on the surface and at various fixed depths. Some AOS can carry a small crew of service personnel and more importantly, to make observations which cannot be performed by self-registering instruments. A small space for two or three experts can easily be provided on a buoy, as in life-buoys.

Apropos of the International (Intergovernmental) Oceanographic Commission's forthcoming decision about the scheme to be adopted for international research, a proposal should be made to make ACS the basis of an international hydrometeorological service in the World Ocean.

The establishment of such a service would make it possible to make simultaneous hydrometeorological observations over the entire water area to be considered. Such stations could gradually be extended to all of the World Ocean. In this way, one could obtain data needed to develop precise methods of calculation for weather forecasting and hydrologic conditions, as well as methods for altering the weather as necessary. The use of AOS would obviate the need for systematic oceanographic surveys by ships, including "weather ships."

Greatly improved methods for data collection, processing, and analysis are prerequisite to acquisition of a thorough understanding of the World Ocean. In studying the Antarctic seas Soviet scientists have for some time been making not only hydrometeorological surveys from ships, repeated several times a year, but also have made considerable use of airplanes for systematic surveys of the ice sheet, hydrologic stations, geophysical research, arrangement of automatic radiometeorological stations on the ice, and of radio surveying rods for study of patterns in ice drift. Recently automatic hydrologic instruments mounted on anchor buoys have also been widely employed /5/. The data obtained by these methods have contributed to studies of the nature of the Arctic Ocean, which has received least attention [of all the oceans] in recent years, and have led to an understanding of the laws governing change in hydrologic conditions from season to season and from year to year /6/.

* In 1948 Ya Ya. Gakkel' and L. P. Samsoniya obtained an author's certificate for the draft of such a station

Existing experience indicates the need for such improvement of oceanologic research methods as would make possible the same kind of forward leap as recently occurred in space study. From a practical point of view, research in the World Ocean is no less important.

Bibliography

1. American Scientist, 47, No. 3, 1959.
2. Stepanov, V.N. Byudzhet (balans) tepla poverkhnosti Mirovogo okeana i teplosoderzhanie ego vod (Thermal Balance of the Surface of the World Ocean and Heat Content of Its Waters). — Trudy Instituta okeanologii AN SSSR, 37. 1960.
3. Stepanov, V.N. Glavneishie sovremennye problemy okeanologii (Major Contemporary Problems of Oceanology). Moskva, Izdatel'stvo "Znanie," 1962.
4. Stepanov V.N. Osnovy metodiki issledovaniya rezhima ledovitykh morei (Basic Methods for Research on the Behavior of the Arctic Seas). — Trudy ANII, 19. 1949.
5. Frolov, V.V. Issledovaniya Sovetskoi Arktiki na sovremennom etape (The Present State of Research in the Soviet Arctic). — Problemy Arktiki, No. 2. 1957.
6. Stepanov, V.N. Kompleksnaya tipizatsiya gidrologicheskogo rezhima morya (Comprehensive Characterization of the Hydrological Behavior of the Sea). — Problemy Arktiki, No. 2. 1957.

T. V. Lobodin

REASONS FOR YEARLY VARIATION OF THE ATMOSPHERIC ELECTRIC FIELD POTENTIAL GRADIENT

The yearly variation of the atmospheric electric field potential gradient E has been reported by various authors /1-6/, but the reasons for the yearly variation of E have not yet been determined. According to most observations carried out in polar regions and over oceans /7-9/, the yearly curve of E reaches extrema at constant times of the year; the maximum in December and January, and the minimum in July — August. These works led to the erroneous assumption that the yearly variation of the potential gradient is connected with the earth — sun distance /4, 9, 10/ A different approach to the interpretation of the yearly variation of E amounts to the following.

At present, the daily unitary variation of E is entirely attributable to the effect of thunderstorms /11/, which is confirmed by the direct correlation between the thunderstorm area on the earth and the potential gradient. The yearly unitary variations of E may apparently also be attributed to the variation of thunderstorm activity over the year /3/. If this is so, there should be a definite direct correlation not only between the daily unitary variations of the potential gradient and the thunderstorm activity, but also between the yearly variations of these quantities.

To verify this according to the data of /12/, the authors of the present work very roughly determined the daily thunderstorm areas over the world for the different seasons. The figure shows the yearly variation of E (curve 1) and of the thunderstorm area of the world (curve 2). We see from the figure that curves 1 and 2 are not parallel; moreover, they are clearly in antiphase. Therefore, the thunderstorm activity cannot be responsible for the yearly variation of E, and it is apparently not the only factor which maintains the negative charge of the earth. It is therefore natural to seek a correlation between the yearly variation of E and some other phenomena. Among these we should clearly consider local variations of electric conductivity λ and of atmospheric volume charges ρ; the local variations of these quantities summed over the entire surface of the earth should give the expected effect.

Let us now determine the component of the yearly variation of E attributable to local variations of electric conductivity, assuming that the variation of E is entirely dependent on this factor. The mean yearly variation of λ for the northern and the southern hemispheres, and also for the oceans is borrowed from /13/. It follows from this work that the yearly variations for the northern and the southern hemispheres constitute 29 % and 8 % of the mean value $\bar{\lambda}$, and that they are in antiphase. For the oceans the amplitude of λ is 3 % of the mean value and the maximum is displaced relative to the extrema of the two hemispheres, so that there is a 2 % variation of λ from winter to summer. Consequently, the variation of λ over oceans need not be considered in this context. The yearly variation of λ for the two hemispheres, with an allowance for the specific weights of the respective continental areas, amounts to some 20 % of the mean and is determined by the variations in the northern hemisphere. If we take into consideration the area of the oceans and the continents in the northern hemisphere, we obtain a global variation of λ amounting to some 6 % of $\bar{\lambda}$.

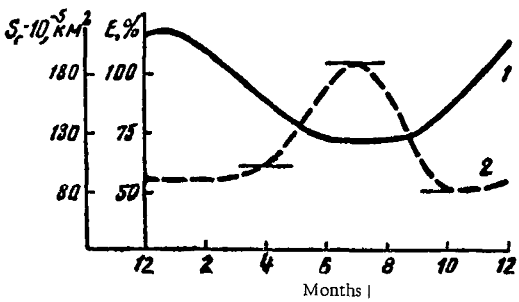


FIGURE 1. Yearly variation of the potential gradient (1) and of the thunderstorm area (2).

Taking into consideration the yearly variations of conduction current and the potential gradient for the oceans and the two hemispheres according to the equation

$$\frac{\Delta i}{i}=\frac{\Delta E}{E}+\frac{\Delta \lambda}{\lambda},$$

where Δ are the yearly variations of the corresponding quantities, we can determine the yearly variation of the potential gradient. The $\Delta E/E$ ratio from this equality is found to be 6 %. It is moreover necessary to allow for the fact that in the 30°N. - 40°S. belt, there is either no yearly variation of E, or else this variation is in antiphase to the yearly variation for the entire world /14/. The global yearly variation of E due to local variations of λ should therefore be reduced to 3-5 %.

The actual yearly variation of E, which is substantially equal to the oceanic component, constitutes 20 % of the mean. Local variations of electric conductivity therefore cannot account for the yearly variation of E.

The only assumption left is that the yearly variation of E is determined by the atmospheric volume charges. The local variations of these charges, especially on the continents, arise from various pollutions of natural and industrial origin, radioactive rays, and also clouds of various forms.

According to the data of aircraft measurements under continental conditions /15/ in a dusty atmosphere, the variation of the electric field over the height indicates the presence of a certain negative volume charge linked with dust particles. If the system earth — atmosphere is regarded as closed, the increase of volume charge in summer in the northern hemisphere should reduce the overall negative charge of the earth. This will lower the potential gradient, as is actually observed. To account for the observed yearly variation of E, the continental ρ should vary by some 3.0 ESU/m^2 over the year.

According to the data of /16/, the atmospheric volume charges under continental conditions may entirely account for the yearly variation of E. It is assumed that there is no yearly variation of ρ over the oceans. Hence, the variation of volume charges in cloudless days does not contribute to the yearly variation of E.

The analysis of the effect of local variations of electric conductivity and of volume charges not related to cloudiness, and also of the relationship of the yearly variation of E and the thunderstorm activity gives the following picture.

The daily unitary variation of E is equal to 43 V/m, and the yearly one to 27 V/m; the former is attributable to thunderstorm activity, while the latter, if we proceed from the same arguments, is entirely independent of it. It remains to be assumed that the two variations are determined not by solar activity alone, but also by some alternative factor. As shown in the preceding, local yearly variations of λ and ρ on clear days cannot account for the yearly unitary variation of E. We should therefore concentrate on the general system of volume charge generation in the atmosphere, including clouds of various forms. In /6, 17/ it was shown that high clouds virtually do not affect the potential gradient near the earth. On the other hand, low clouds vary E considerably. Direct aircraft measurements of the electric structure of lower stratus, whose results are given in /18/, show that in 77% of dipole clouds the charge distribution coincides with that in thunderstorm clouds. Let us now compare the terrestrial charging currents contributed by thunderstorm and by stratus clouds. Borrowing the stratus charge from /18/ and taking the extent of the cloud as 30-40 km^2, we obtain a stratus charge of $(5\text{-}10)\cdot 10^7$ESU. The charge of a thunderstorm cloud is thus 200-300 times as high as the charge of a stratus cloud of the same size. It follows from /12/ that continental thunderstorm clouds occupy some 1/600 to 1/500 of the world surface area. If all thunderstorm clouds had dipole structure, with the positive charge concentrated in the upper and the negative charge in the lower part, stratus clouds should occupy approximately half the world to set up the same current. To equate the actual effects of thunderstorm and stratus clouds, it suffices that the latter occupy only one sixth of the world. In reality, stratus clouds occupy much greater areas /19/.

The basic argument generally quoted in favor of the thunderstorm theory, which explains the correlation between the unitary variation of E and the thunderstorm area, is the results of current measurements above thunderstorms /20/. However, the fact that not all thunderstorm clouds are positive from above and negative from below has been formerly neglected. If we take into consideration the varying polarization of thunderstorm clouds, we may come to the conclusion that the commonly accepted charging currents attributable to thunderstorms have been substantially exaggerated. The data of this paper clearly should be worked out in more detail, proceeding from more numerous observations of thunderstorm and rain clouds. It seems, however, that the thunderstorm mechanism alone cannot account for the electric field in fair weather.

Bibliography

1. Zukova, V.V. Gradient elektricheskogo potentsiala v Yuzhno-Sakhalinske za 1933-1946 gg. (Electric Potential Gradient in Yuzhno-Sakhalinsk in 1933-1946). — Trudy GGO, Vol. 58(120). 1956.
2. Kulagin, D.N. O godovom khode gradienta elektricheskogo polya atmosfery (The Yearly Variation of the Atmospheric Electric Field Gradient). — Meteorologiya i Gidrologiya, No. 7. 1953.
3. Paramonov, N.A. O godovom khode gradienta atmosfernoelektricheskogo potentsiala (The Yearly Variation of the Atmospheric Electric Potential). — DAN SSSR, Vol. 20, No. 1. 1950.
4. Tverskoi, P.N. Atmosfernoe elektrichestvo (Atmospheric Electricity). — Gidrometeoizdat, Leningrad. 1949.
5. Simpson, G.S. British Antarctic Expedition 1910-1913. Meteorol., 1, Calcutta. 1919.
6. Mauchli, S.I. Studies in Atmospheric Electricity Based on Observations Made on Carnegie 1915-1921. Res. Dep. Terr. Mag., 5. 1926.
7. Gerasimenko, V.I. Osobennosti elektricheskogo polya v Arktike (Peculiarities of the Arctic Electric Field). — Abstract, ANII, Leningrad. 1956 (manuscript rights).
8. Rey, I.I. Note sur les résultats des observations d'électricité atmospherique. Le "Français" en Pole sud. Paris. 1906.
9. Rouch, I. Observations d'électricité atmosphérique faites dans l'Antarctique pendant l'expédition Charcot (1909). Ann. Soc. Météor Fr., 54. Paris. 1911.
10. Rey, I.I. Observations d'électricité atmosphérique sur la Terre de Graham et variation du champ à la surface du globe. Ann. Soc. Météor. Fr. Paris. 1906.
11. Wilson, C.T.R. The Maintenance of the Earth's Electric Charge. The Observatory, 45. 1922.
12. Ramakrishnan, K.P. and D.S.V. Rao. Distribution of Thunderstorms over the World. Ind. J. Meteor., Geoph., 1. 1955.
13. Paramonov, N.A. Thesis. — GGO, Leningrad. 1954 (manuscript rights).
14. Benndorf, G. Atmospheric Electricity. [Russian translation. 1934.]
15. Imyanitov, I.M. and E.V. Chubarina. Khod napryazhennosti elektricheskogo polya v atmosfere s vysotoi v yasnye dni (po rezul'tatam izmerenii vo vremya MGG) (Variation of Atmospheric Electric Field Strength over the Height in Clear Days (from the results of IGY measurements)). — Trudy GGO, No. 110. 1960.
16. Imyanitov, I.M. and E.V. Chubarina. Nekotorye rezul'taty issledovaniya elektricheskogo polya atmosfery a pomoshch'yu samoletov i sovremennye vozzreniya na ego proiskhozhdenie (Some Results of Aircraft Measurements of the Atmospheric Electric Field and Modern Conceptions of its Origin). — Materialy konferentsii po itogam MGG (1960) i meteorologicheskogo izucheniya Antarktidy (1959), Gidrometeoizdat, Leningrad. 1961.
17. Lobodin, T.V. Meridional'nyi razrez gradienta potentiala atmosfery po nablyudeniyam nad okeanami vo vremya MGG (Meridional Section of the Atmospheric Potential Gradient from IGY Oceanic Observations). — Trudy GGO, No. 110. 1960.

18. Imyanitov, I. M. and E. V. Chubarina. Elektricheskaya struktura nedozhdyashchikh sloistykh obtakov nizhnego yarusa (Electric Structure of Nonrain Lower Stratus). — Trudy GGO, No. 136. 1962.
19. Shaw, N. Manual of Meteorology, 2. Cambridge. 1936.
20. Stergis, C. C., G. S. Rein, and T. Kangas. Electric Field Measurements above Thunderstorms. J. Atmosph. Terr. Phys., 11, No. 2. 1957.

T. V. Lobodin

RELATIONSHIP OF THE INTENSITY OF THE ELECTRIC FIELD OF THE ATMOSPHERE WITH POLAR AURORAE

During the IGY observations of the intensity of the electric field of the atmosphere were made at the Mirny antarctic observatory (66°S. and 93°E.). The field intensity *E* was measured with an electrostatic fluxmeter /1/ with continuous recording on an electronic potentiometer. Besides the unitar daily and yearly variations of *E*, the study of electricity in fair weather included investigation of the behavior of the electric field during polar aurorae. The data presented in this paper on variation of electric field during polar aurorae are based on the material collected during 81 hours of continuous observations.

Until now there is no single, universally accepted point of view on the effect of polar aurorae on the atmospheric electric field near the earth's surface. Some authors /2-4/ maintain that polar aurorae lower the intensity of the electric field, others /5/ accept the existence of obvious relationships between *E* and polar aurorae and do not support this reduction, still other investigators /6/ point to the lack of any relationship between the variation of *E* and the occurrence of polar aurorae. It is noteworthy that the observations of electric field during polar aurorae are few and most of them have been made in arctic regions.

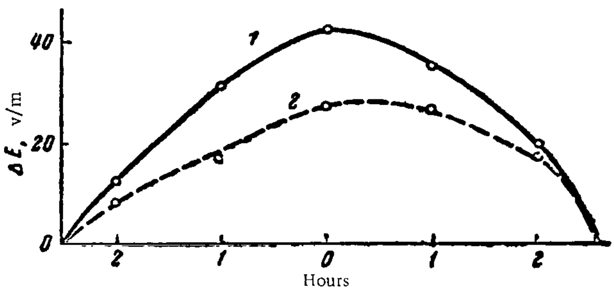
To study the factors responsible for the relationship of polar aurorae with the atmospheric electric field, it is necessary to compare observations made in arctic and antarctic regions. If we accept, following /2-4/, that polar aurorae reduce *E* at all points of the earth, it would seem that this reduction is due to the increase of the electric conductivity of the atmosphere owing to the enhanced ionization. If polar aurorae have a different effect on *E* in the northern and in the southern hemispheres, the variation of the electric field can be related to particles of unlike charge deflected to the poles by the magnetic field of the earth.

In observations at the Mirny observatory, which is located on the maximum isochasm /7/, the author obtained an increase of *E* during polar aurorae, whereas the results for the northern polar circle point to a decrease of *E*. Polar aurorae thus behave as a positive volume charge in the southern hemisphere and as a negative charge in the northern hemisphere.

The experimental data on the variation of *E* during polar aurorae at Mirny are plotted in the figure. The ordinate gives the increment of the positive magnitude of field intensity, and the abscissa marks time in hours. Time is reckoned from the moment of polar aurora: the 0 point corresponds to the occurrence of an aurora, the figures 1 and 2 marking hours before and after the onset of aurorae. The curves in the figure have been smoothed out using the formula

$$\frac{a + 2b + c}{4},$$

It seems that the treatment of electric intensity observations during polar aurorae requires a special approach. Indeed, we know /8, 9/ that there are unitary daily and yearly variations of E. In the course of daily unitary variations E attains maximum at 1800-1900 hrs, and minimum at 0600-1000 hrs universal time /10/. In unitary yearly variations E is maximum in northern winter and minimum in summer. The amplitude of the unitary daily and yearly variations of E is approximately of the same order of magnitude as the increment of E during polar aurorae. The yearly unitary variation need not be considered when we are concerned with the variation of E over a few hours before and after the onset of polar aurora. The daily unitary variation, however, must be explicitly allowed for in this method.



Variation of the intensity of the atmospheric electric field during polar aurorae.

1 — uncorrected for daily unitary variation; 2 — corrected for daily unitary variation.

Since polar aurorae are observed during the nocturnal periods only, the accepted method of treatment of observational data on the electric-field intensity would invariably detect a decrease of intensity in the 60°-120°W. longitude sector and an increase of E in the 60°-120°E. sector, even if the aurorae did not affect the intensity E. These variations of E may arise because the maximum frequency of polar aurorae during each 24-hour period coincides with the minimum or the maximum of the unitary daily variation of E.

To show how corrections for unitary daily variation distort the value of E during polar aurorae, the figure gives the values of E during polar aurorae with (curve 2) and without (curve 1) allowance for this factor. At the Mirny observatory the maximum of unitary variation approximately coincides with the maximum frequency of polar aurorae, so that the maximum correction applies during the aurora. Comparison of the two curves leads to the conclusion that the correction for unitary variation of represents about 60 % of the overall increment of E.

Universal time, hrs	E, v/m	Universal time, hrs	E, v/m	Universal time, hrs	E, v/m
1	8	9	15	17	-24
2	7	10	14	18	-26
3	8	11	13	19	-24
4	11	12	13	20	-19
5	14	13	6	21	-12
6	16	14	- 5	22	- 4
7	17	15	-13	23	2
8	16	16	-19	24	5

The table gives numerical values of corrections for daily unitary variation of E. The E in volt/m should be added to the daily average values of E. These data were obtained by the author in his measurements of the electric-field intensity in the Pacific and the Atlantic oceans during 1957-1959.

Bibliography

1. Imyanitov, I.M., V.V. Mikhailovskaya, V.V. Ziganov, and M.B. Strel'tsova. Pribor dlya izmereniya napryazhennosti polya atmosfery v slozhnykh meteorologicheskikh usloviyakh (Apparatus for Measuring the Atmospheric Field Intensity under Complex Meteorological Conditions). — Izvestiya AN SSSR, seriya geofizicheskaya, No. 9. 1956.
2. Gerasimenko, V.I. Atmosferno-elektricheskie issledovaniya na myse Chelyuskina v 1934/35 g. (Atmospheric-Electric Investigations at the Chelyuskin Cape during 1934-1935). — Trudy ANII, Vol. 97. 1937.
3. Paramonov, N.A. Osnovnye zakonomernosti izmeneniya gradienta potensiala elektricheskogo polya atmosfery (Principal Regularities in the Variation of the Atmospheric-Electric Potential Gradient). — Thesis, GGO, Leningrad. 1954.
4. Scholz, I. Luftelektrische Messungen auf Franz-Josef-Land wahrend des II Internationalen Polarjahres 1932-1933. — Trudy ANII, Vol. 16. 1935.
5. Rusinov, B.Sh. and P.N. Tverskoi. K voprosu o svyazi mezhdu napryazhennost'yu elektricheskogo polya i polyarnymi siyaniyami (The Relationship Between the Electric-Field Intensity and Polar Aurorae). — Trudy GGO, No. 18. 1952.
6. Sverdrup, H.U. Observations of the Atmospheric-Electric Potential Gradient 1922-1925. — Res. Dep. Terr. Mag., Vol. 5. 1926.
7. Tverskoi, P.N. Atmosfernoe elektrichestvo (Atmospheric Electricity). — Gidrometeoizdat, Leningrad. 1949.
8. Mauchly, S.I. Studies in Atmospheric Electricity Based on Observations Made on Carnegie 1915-1921. — Res. Dep. Terr. Mag., Vol. 5. 1926.
9. Rey, I.I. Expedition Antarctique Française 1903-1905. — Physique du Globe, Paris. 1911.
10. Lobodin, T.V. Nekotorye rezul'taty issledovanii elektricheskogo polya nad okeanami (Some Results of the Electric Field over Oceans). — Trudy GGO, Vol. 97. 1960.

Yu. N. Avsyuk and Yu. D. Bulanzhe

INITIAL GRAVIMETRIC BASES IN THE ANTARCTICA

Fairly numerous gravimetric bases have been established in the Antarctic. The various data concerning the force of gravity accumulated at these bases cannot be applied effectively unless reduced to a common system.

The Mirny settlement, with its airfield and provision for anchorage, is the main home base of Soviet expeditions in the Antarctic. The main gravimetric base was therefore established here and is used as point of reference for all the Soviet determinations of gravity in the Antarctic. It is located in the cosmic-ray observatory, on a concrete block serving as the fundament of an ASK-2 ionization chamber. The coordinates of this base are: φ = 66°33.2' S.; λ = 93°00.9' E.; H = 20.7 m.

During 1958, D. Sparkman obtained for this base g = 982,407.4 ± 2.0 mgl (in the Potsdam system). The measurements were made with the La Costa gravimeter. Initial base — Washington. This result should be considered as preliminary, subject to further refinement in the future. At present, however, this value should be taken as the point of reference for all gravimetric determinations in the Antarctic.

SN-3 gravimeters were used to determine the increments of the force of gravity between intracontinental Soviet Antarctic stations. The results of these determinations were reduced to the g-value for Mirny obtained by Sparkman (see Table).

Base	φ, S.	λ, E	H, m	g, mgl	± mg, mgl
Pionerskaya	69°44'	95°30.0'	2740	981,846.6	2.3
Vostok-1	72°08.6'	96°36.8'	3250	981,782.5	2.2
Komsomol'skaya .	74°05.0'	97°29.0'	3500	981,768.5	2.1
Vostok	78°27'	106°52	3490	981,909.9	2.1
Sovetskaya	78°24'	87°35'	3660	981,870.4	2.1

The reliability of these determinations was confirmed by transmitting the values of the acceleration of the force of gravity from Mirny through the bases Pionerskaya, Vostok-1, Komsomol'skaya, and Vostok to the Amundsen-Scott station (U. S. A.). The discrepancy between the value of transmitted from Mirny with the previously determined g transmitted from Washington was found to be 3.0 mgl. This is consistent with the errors indicated in the table.

Observations at intracontinental stations were made on the snow surface of airfields near the respective stations. Since the airfield level may vary considerably owing to accumulation and transport of snow, these g-values whenever used as initial data, must be corrected for the actual height of the observation point.

Sparkman's g for Mirny was taken as the initial value in treatment of gravimetric observations made during intracontinental trips, and also in gravity determinations in coastal regions.

Using this g-system, the Aerogravimetric Laboratory of the Institute of Physics of the Earth im. O. Yu. Shmidt of the Academy of Sciences of USSR issued a comprehensive catalog of gravimetric bases established in the Antarctic up to 1 January, 1962. The catalog was compiled using the data of all the countries taking part in gravimetric research in the Antarctic. The data of this catalog were used as the basis of gravimetric mapping of the Antarctic.

P. B. Babadzhanov, L. A. Katasev,
V. P. Konopleva, and E. N. Kramer

DENSITY, TEMPERATURE, AND PRESSURE OF THE ATMOSPHERE FROM PHOTOGRAPHIC OBSERVATIONS OF METEORS

During the IGY various astronomical organizations in the USSR obtained in the course of photographic observations of meteors a large body of data which have not yet been treated conclusively. However, partial results are already available.

A résumè has been prepared of data on atmospheric density obtained by E. N. Kramer in consequence of treatment of photographs of 50 meteors observed in Odessa between 1957 and 1958; another résumé drawn by P. B. Babadzhanov contains data on density and height of homogeneous atmosphere obtained in treatment of photographs of 34 meteors taken in Dushanba during 1957. Results are also available on the ten meteors observed in Kiev during the same year /1, 2/.

E. N. Kramer's results on atmospheric density are listed in Table 1. The following formula was used in calculations

$$P = -k_1 v^{-3} \frac{dv}{dt} \left[\int_{t}^{t_k} I\, dt \right]^{1/3} \tag{1}$$

where v is velocity; dv/dt the deceleration; I the luminous intensity of the meteor; and k_1 a proportionality coefficient.

It was assumed in calculations that

$$\lg k_1 = 6.285, \ \lg I = 0.4\, M,$$

where M is the absolute stellar magnitude.

TABLE 1

h, km	lg ρ	h, km	lg ρ
65.1	-7.11 ± 0.08	92.1	-8.10 ± 0.16
72.6	-6.89 ± 0.06	97.5	-8.21 ± 0.09
77.7	-7.59 ± 0.02	97.6	-8.30 ± 0.09
78.0	-7.14 ± 0.12	101.7	-8.54 ± 0.08
82.1	-7.71 ± 0.18	102.4	-8.45 ± 0.06
82.5	-7.63 ± 0.08	107.5	-8.96 ± 0.11
87.6	-7.13 ± 0.13	108.2	-8.80 ± 0.10
87.8	-7.71 ± 0.10	110.5	-9.54 ± 0.11
92.0	-7.94 ± 0.10	111.2	-9.08 ± 0.14

The data obtained by P. B. Babadzhanov are given in Tables 2 and 3. The atmospheric density was determined with an allowance for the deceleration of the meteors from the formula

$$P = -k_2 m^{1/3} v^{-2} \frac{dv}{dt}, \tag{2}$$

where m is the mass of the meteoric particle determined from photometric measurements:

$$m = -\frac{2}{\tau_o v^3} \int_t^{t_k} I\,dt. \tag{3}$$

The coefficient k_2 was taken as unity. Here

$$\lg \tau_0 = -9.07, \ \lg I = 9.84 - 0.4\,M. \tag{4}$$

The density was determined from the initial points of the meteor trail using the formula

$$\lg P = \lg k_3 - 0.4\,M - 6 \lg v - \frac{2}{3} \lg m; \tag{5}$$

where $\lg \rho_3 = 31.08$. These data are listed in Table 3.

TABLE 2

h,km	$\lg \rho$	h,km	$\lg \rho$	h,km	$\lg \rho$
69.2	-7.60	82.0	-6.98	88.0	-8.01
70.0	-7.42	83.2	-8.27	90.2	-7.58
70.1	-7.22	83.4	-7.05	90.8	-6.96
74.0	-7.65	83.4	-6.71	93.2	-7.58
75.2	-6.91	83.8	-7.07	93.5	-8.10
76.8	-7.47	84.2	-8.03	95.7	-8.04
81.6	-7.32	86.1	-7.47	99.6	-9.55

TABLE 3

h,km	$\lg \rho$	h,km	$\lg \rho$	h,km	$\lg \rho$
74.0	-6.70	88.0	-7.91	97.6	-8.61
76.9	-6.36	88.1	-7.87	97.8	-8.09
77.6	-7.01	88.4	-7.63	97.9	-8.84
81.9	-6.69	91.4	-7.82	100.8	-8.64
82.8	-7.60	91.6	-7.19	104.1	-8.51
84.5	-7.25	91.8	-7.43	104.2	-8.20
85.0	-7.72	93.3	-7.31	105.3	-8.81
85.1	-7.49	95.2	-7.44	105.4	-8.49
85.4	-8.18	95.4	-8.61	111.2	-8.92
85.6	-8.50	95.8	-7.91	112.9	-8.99
86.5	-8.07	96.7	-8.35	114.8	-8.73
87.1	-7.62				

The data listed in Tables 1, 2, and 3 were used to determine the average values $\overline{\lg \rho}$ for the corresponding height intervals indicated in Table 4. The same table also gives the average values $\overline{\lg \rho}$ obtained by V.N. Konopleva from formula (2); the proportionality coefficient was taken equal to 0.863.

The results of E.N. Kramer and V.P. Konopleva listed in Table 4 were obtained in the following system of units:

$$\lg I = -0.4M, \ \lg \tau_0 = -8.19; \tag{6}$$

the results of P.B. Babadzhanov assume (4). It follows from reference /2/ that the application of systems of units (4) or (6) leads to a systematic difference of 0.24 in $\lg \rho$.

TABLE 4

Altitude range h in km	Averages according to E.N. Kramer		Averages according to P.B. Babadzhanov		Averages according to V.P. Konopleva	
	$\bar{h}$, km	$\overline{\lg \rho}$	$\bar{h}$, km	$\overline{\lg \rho}$	$\bar{h}$, km	$\overline{\lg \rho}$
65-70	65.1	-7.11 ± 0.08	69.1	-7.60		
70-75	72.6	-6.89 ± 0.06	73.0	-7.07 ± 0.42		
75-80	77.8	-7.36 ± 0.07	76.5	-7.14 ± 0.23	79.6	-7.8
80-85	82.3	-7.67 ± 0.13	83.1	-7.32 ± 0.37	82.6	-7.21
85-90	87.7	-7.42 ± 0.11	86.7	-7.82 ± 0.29	86.2	-7.50 ± 0.05
90-95	92.0	-8.02 ± 0.13	92.0	-7.60 ± 0.38		
95-100	97.5	-8.20 ± 0.09	96.8	-8.38 ± 0.49	97.2	-8.00 ± 0.10
100-105	102.0	-8.50 ± 0.07	103.0	-8.45 ± 0.17	101.9	-8.52 ± 0.19
105-110	107.8	-8.88 ± 0.10	105.4	-8.65 ± 0.16		
110-115	110.8	-9.31 ± 0.12	113.0	-8.88 ± 0.10		

The data of Table 4 are plotted in Figure 1; here the results of P.B. Babadzhanov, as listed in the table, have been corrected by -0.24. We see from the figure that the data of all three authors for altitudes > 70 km are in good agreement with the NASA curve /3/ and show a systematic departure from the data of VSA-60 tables /4/. This is apparently due to the fact that the authors of the present paper used the proportionality coefficients entering the working formulas for the determination of $\lg \rho$ as derived by F. Whipple and L. Jacchia /3/ by correlating the meteoric data with the NASA curve. The dark circles in this figure give the individual values of $\lg \rho$ determined by V.P. Konopleva for the same meteors using the formula

$$\rho = \frac{\alpha m^{1/3} v^{-2} \frac{dv}{dt}}{C_{\tau} + \bar{k} \frac{\alpha}{Q} v v_{t}} \tag{7}$$

which can also be written in the form

$$\rho = -k m^{1/3} v^{-2} \frac{dv}{dt}, \tag{8}$$

where

$$k = \frac{\alpha}{C_x + \bar{k}\,\frac{a}{Q} v v_t} = \frac{1.647\,\delta^{2/3}}{C_x + \bar{k}\,\frac{a}{Q} v v_t} \tag{9}$$

In (7) and (8) $\alpha = 1.647\,\delta^{2/3}$ (δ is the density of the meteoric body); C_x is the aerodynamic drag factor; a is the accommodation coefficient; Q, the energy required to heat and vaporize one gram of meteor substance, v_t, the average thermal velocity of the evaporating molecules; and $\bar{k}$, a proportionality coefficient. In calculations the following values were assumed: $\delta = 3$, $a = 1$, $Q = 1.04 \cdot 10^{10}$ erg/g, $v_t = 1.4 \cdot 10^5$ cm/sec, $\bar{k} = 4/9$, $C_x = 2.7$.

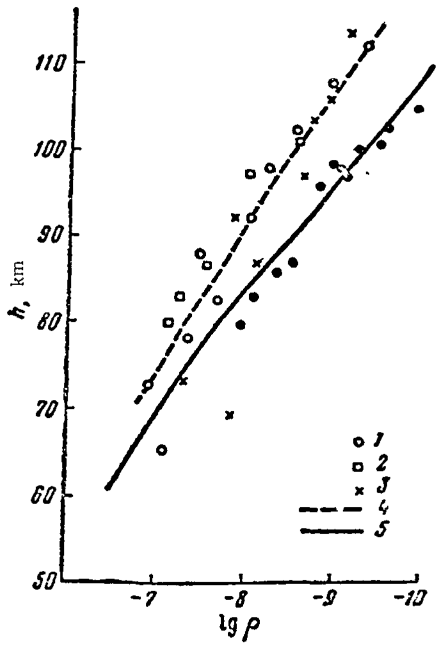


FIGURE 1. Atmospheric density vs. altitude

1 — from meteor observations in Odessa (Kramer); 2 — in Kiev (Konopleva); 3 — in Dyushambe (Babadzhanov); 4 — data of NASA tables; 5 — data of VSA-60.

The form of formulas (8) and (2) is almost identical. The coefficients k_2 and k, however, are essentially different:

$$k_2 = \frac{1.647\delta^{2/3}}{C_x} \tag{10}$$

We see from Figure 1 that in this case the calculated values of $\lg \rho$ are in good agreement with VSA-60. It would consequently be interesting to treat the results of other authors also using formula (8). Unfortunately, we were only able to carry out this procedure for the data of P. B. Babadzhanov, which provide us with all the necessary initial quantities. The average values of $\lg \rho$ according to the data of V. P. Konopleva and P. B. Babadzhanov obtained in this manner are given in Table 5. The results refer to the 75-105 km range, since the observations at altitudes < 75 km are very few, and no observations were made at altitudes > 105 km.

TABLE 5

Height interval, km	$\bar{h}$, km	$\lg \rho$	$\lg \rho_{cal}$
75-80	77.2	-7.64 ± 0.32	-7.40
80-85	82.7	-7.71 ± 0.48	-7.81
85-90	86.6	-8,24 ± 0.24	-8.12
90-95	92.1	-8.18 ± 0.53	-8.55
95-100	97.3	-9.06 ± 0.33	-8.97
100-105	102.2	-9.36 ± 0.26	-9.35

The data of Table 5 are plotted in Figure 2. The average values of $\lg \rho$ are marked by crosses, the horizontal bars indicating the mean error in pinpointing the average; the solid line traces the results of VSA-60 tables.

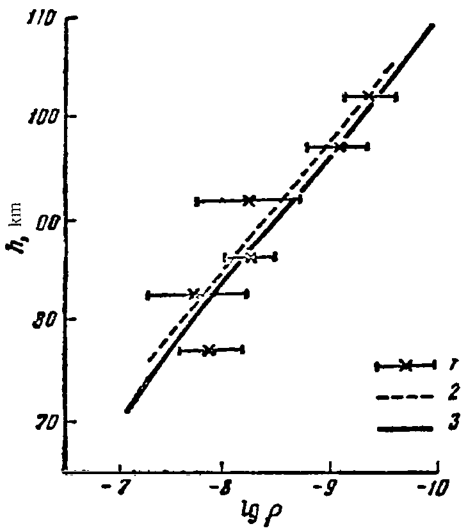


FIGURE 2. Average densities (1) vs. altitude

2 — obtained by the least-squares method from the meteoric observations; 3 — VSA-60 data.

Assuming linear dependence of $\lg \rho$ on h at these altitudes, we used the method of least squares to obtain $\lg \rho_{cal}$ from the average values $\overline{\lg \rho}$. These figures are given in the last column of Table 5 and are marked by the broken line in Figure 2. In this case the meteoric data show good fit with the VSA-60 tables.

The height of the homogeneous atmosphere H^* was calculated by P. B. Babadzhanov and V. P. Konopleva from the formula

$$H = \frac{3\upsilon \cos Z_R}{I}\left[1 - \left(\overline{\alpha}\ \frac{\int_{t_k}^{t_n} I\,dt}{\int_{t_k}^{t} I\,dt}\right)\right]\int_{t_k}^{t} I\,dt \tag{11}$$

where Z_R is the zenith distance of the meteor radiant, $\alpha = 1.135$. The values of H^* are given in Table 6. This table also shows the average values $\overline{H}^*$.

TABLE 6

h, km	H^*, km according to P. B. Babadzhanov	H^*, km according to V. P. Konopleva	$\overline{H}^*$, km	$\overline{T}$ °K	p, mm Hg
70	7.30	6.87	7.08 ± 0.21	237	
75	6.35	6.63	6.49 ± 0.14	216	$2.51 \cdot 10^{-2}$
80	5.65	6.32	6.00 ± 0.32	200	$7.65 \cdot 10^{-3}$
85	5.20	6.25	5.72 ± 0.53	190	$4.10 \cdot 10^{-3}$
90	5.10	6.13	5.61 ± 0.52	187	$1.62 \cdot 10^{-3}$
95	5.45	6.00	5.72 ± 0.28	190	$6.48 \cdot 10^{-4}$
100	6.05	5.88	5.96 ± 0.06	198	$2.69 \cdot 10^{-4}$
105	6.70	5.85	6.27 ± 0.32	208	$1.12 \cdot 10^{-4}$

The absolute temperatures were calculated from the average heights $\overline{H}^*$

$$\overline{T} = \frac{\mu g}{R}\overline{H} \tag{12}$$

where μ is the molecular weight of air taken as 29, g, the acceleration due to gravity, and R, the gas constant. The temperature is given in the last but one column of Table 6 and is plotted in Figure 3. For comparison purposes the solid line in this figure shows the data of VSA-60 tables.

If ρ and T or $\overline{H}^*$ are known, the atmospheric pressure ρ can be obtained:

$$p = \frac{\rho R T}{\mu} = \rho H^*_g \tag{13}$$

The calculated values of p obtained from the data of Tables 5 and 6 are listed in the last column of Table 6 and are marked by circles in Figure 4; the solid line gives the data of VSA-60 tables.

It follows from the preceding that the meteor method makes it possible to determine, from photographic observations of meteors, the density, temperature, and pressure of the atmosphere at heights of 70-115 km. However, to ensure satisfactory application of the method, the theory on which the treatment of observations is based must be perfected. In this context it is highly desirable to make simultaneous measurements of the thermodynamic parameters of the atmosphere in this height interval using rocket and meteor methods in parallel.

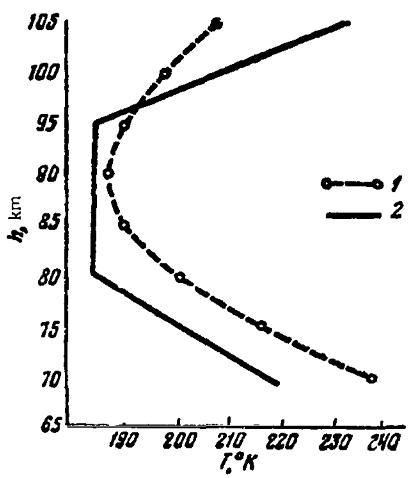


FIGURE 3. Atmospheric temperature vs. altitude.
1 — from meteoric observations; 2 — VSA-60 data.

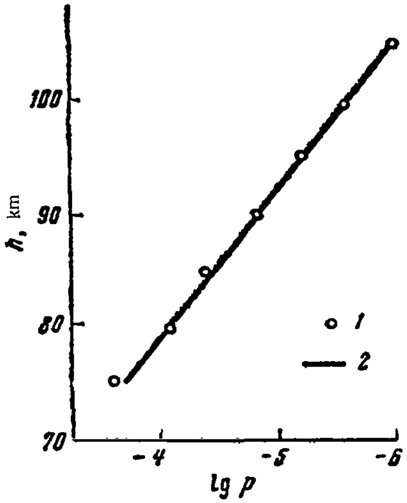


TABLE 4. Atmospheric pressure vs. altitude.
1 — from meteoric observations; 2 — VSA-60 data.

Bibliography

1. Benyukh, V.V., A.A. Gavlovskaya, V.P. Konopleva, Yu.N. Krivutsa, V.G. Kruchinenko, E.V. Sandakova, and A.K. Terent'eva. Fotograficheskie nablyudeniya meteorov na observatorii Kievskogo universiteta v 1957 g. (Photographic Observations of Meteors at the Kiev University Observatory during 1957). — In: Sbornik rabot po Mezhdurnarodnomu geofizicheskomu gody, Vol. 1, p. 3, Izdatel'stvo Kievskogo universiteta. 1961.
2. Konopleva, V.P. Plotnost' zemnoi atmosfery po fotograficheskim nablyudeniyam metsorov v 1957 g. (Atmospheric Density from Photographic Observations of Meteors during 1957). —In: Sbornik rabot po Mezhdunarodnomu geofizicheskomu gody, Vol. 1, p. 16, Izdatel'stvo Kievskogo universiteta. 1961.
3. Jacchia, L.G. — Technical Report No. 4. Harvard Reprint, Ser. 11-32. 1949.
4. Tablitsa vremenoi standartnoi atmosfery 1960 g. (VSA-60) (Table of Temporal Standard Atmosphere of 1960. — Vychistitel'nyi tsentr AN SSSR, Moskva. 1960.

G. E. Lazarev

TRIGONOMETRIC LEVELING ON THE KOMSOMOL'SKAYA-SOVETSKAYA-VOSTOK-KOMSOMOL'SKAYA PROFILE

Since the beginning of the International Geophysical Year (1957-1958), extensive scientific research has been conducted in the Antarctic. The systematic study of all the processes and phenomena (aerometeorological, geophysical, etc.) made evident the need for an exact determination of the height of the ice cap and particularly of the altitude of the stations located in the interior of the continent. Barometric, aerial, and radio leveling methods are the least laborious ways of doing so, but their accuracy is low, with errors sometimes reaching 100 m.

Hitherto trigonometric leveling has been used only in small parts of the coastal districts. The Fourth SAE did the first geodesic work on height determination of a profile of considerable length (870 km).

In spite of great difficulties and unfavorable physical and geographical conditions, the geodesic team determined the height of 259 points, including Pionerskaya, Vostok-1, and Komsomol'skaya stations.

A geodesic and gravimetric group to continue this research was included in the Sixth SAE on the suggestion of Yu. D. Bulanzhe (Dr. Phys. Mat. Sci.). Between 12 November, 1961 and 11 January, 1962, the group performed trigonometric leveling along the triangle Komsomol'skaya-Sovetskaya-Vostok-Komsomol'skaya.

This article will briefly describe the special features of the method of observation, and some of the physical and geographical findings in the region studied.

The route lay through a desert almost totally lacking in orientation points, at an altitude of more than 3500 m, in severe climatic conditions. The region is characterized by almost impassable loose snow and very low temperatures. This point requires more detailed discussion since the snow cover and climatic conditions not only complicate the organization of the work, but also affect the accuracy of the geodesic measurements.

It is known that the density and hardness of the snow gradually decrease as one moves away from the belt of the strongest katabatic winds into the interior of the continent. The density of the surface snow between Komsomol'skaya and Sovetskaya averages 0.36 to 0.37 g/cm^3, and the hardness does not usually exceed 1 kg/cm^2. However, 10 to 20 cm below the crust there is a layer of loose fine-grained snow with a very low load capacity. This crust is easily broken by tractors, which sink into the snow making tracks as much as 0.5 m deep. During the traverse, one sledge (with a total weight of less than 20 tons) had to be towed by two tractors at a speed of 4 to 5 km/hour, which resulted in a great increase in fuel consumption. The fuel consumption of a heavy Antarctic tractor was 12 to

14 l/km, while "Pingvin" all-terrain vehicles consumed 6 l/km.

On the Komsomol'skaya-Sovetskaya-Vostok route the vehicles sank a good deal, and a loud rumble was heard, evidently indicating that the snow layer below the crust is very loose, and cannot support even a small unit load. The subsidence of the snow and of the machines used to make measurements was hard to determine, owing to the randomness and brevity of the phenomenon.

Low temperatures have considerable effect on passability. According to the investigations of S.N. Kavtashov, at temperatures of -30°C to -50°C, the mechanical friction at the points of contact between runner and snow does not fuse the crystals, as a result of which no "liquid lubricant" is formed between the moving surface and the snow, and the friction is very high. Our sledges with steel-covered runners had a greatly increased coefficient of friction, owing to the high heat conductivity of the metal, which promoted great heat dissipation. Considerable tractive force is required to tow such sledges. Dural sledges, with Teflon-covered runners were good sliders, and between Vostok and Komsomol'skaya such sledges (with a total weight of over 25 tons) were comparatively easily towed by a single heavy tractor, with diesel fuel consumption of less than 8 l/km.

To describe the condition of the atmosphere, concise data on the pressure, temperature, humidity, cloudiness, and visibility will be given. These factors affect human activity, the functioning of instruments and vehicles, the accuracy of altitude determination, and refraction research.

A high pressure region is almost always to be noted in the interior of Antarctica. Variation in the average monthly values of atmospheric pressure is hardly noticeable, and the greatest pressure fluctuations are observed in the winter. In July 1963 the extreme values of 484.1 and 453.4 mm Hg were recorded at Vostok. In the summer the fluctuations are comparatively small, and in January the maximum pressure recorded was 484.0 and the minimum, 468.9 mm Hg. The average monthly temperature at all the stations in the interior of the continent is below zero the year round. The fluctuations of the air temperature are greater in winter than in summer, due to circulation conditions. The maximum and minimum temperatures observed at Vostok in 1961 were -36.1° and -80.2°, respectively, in July, and -27.5° and -34.0° in December. The lowest temperature ever recorded there, in 1960, was -88.3°.

Comparatively constant pressure distribution and other local conditions result in high stability of the wind direction. Easterly and southeasterly winds, which are the strongest, predominate throughout the year at Pionerskaya, Vostok-1, and Komsomol'skaya. The 1961 observations indicate the prevalence of west-south-westerly winds at Vostok.

The wind velocities are typically minimum in summer and maximum in winter. In the coastal region hurricane winds are often encountered but in the interior the winds are considerably weaker. The maximum wind velocity at Vostok in 1961 was 14 m/sec, recorded in October. Only five days with storm winds (> 15 m/sec) were recorded at Sovetskaya over ten months of 1958. Owing to the low temperatures, the quantity of water vapor in the air is very small. In 1957 the absolute humidity in the interior of the continent varied between 0.13 millibars in the summer and 0.02 millibars in the winter. Cloudiness in the central regions is rare. Upper-level clouds (cirrus and cirrostratus) through which the sun and often bright stars and planets are visible, predominate.

Extraordinary transparency, absolute purity of the air, and hence excellent visibility, are peculiar to the Antarctic, although visibility is often limited by drifting blizzards, ground-winds, snow-falls, fog, and haze. If the snow is loose, mild blizzards can arise at a wind velocity of 5 m/sec. Drifting blizzards on a large scale can be observed in the inner regions and on the coast when snow is falling and the wind velocity reaches 10 m/sec. The fiercest blizzards occur in the colder half of the year.

Frosty fog or haze, caused by the process of sublimation and condensation of atmospheric moisture in the form of ice crystals or ice dust and hoar-frost, are often observed in the interior of the continent, mostly in the cold part of the year. In 1961, 140 days of haze and 237 days of ice fogs were recorded at Vostok, but of those, only 11, 6, and 14, respectively, occurred in the three summer months — November, December, and January.

The physical and geographical factors indicated above were a source of both difficulties and progress. Owing to the low temperature and the great distance of the starting point of the work from the main base (Mirny), work had not even begun by the end of the first field season. When autumn came, the temperatures fell as low as -62°C, and the axes of the theodolites could revolve only with difficulty.

It seemed doubtful that all of the work could be completed in a single spring field season, and a traverse of 1540 km, including geodesic and other observations, made. Previous expeditions had not worked at such a pace. The glaciological expedition in the interior of the continent of the Second SAE covered only 370 km, instead of the 1000 km planned. The geodesic and gravimetric section of the Fourth SAE accomplished its work on a profile of 870 km. The only large-scale journeys were for purposes of transport: Mirnyi-Vostok in the second KAE, Komsomol'skaya-Pole of Relative Inaccessibility, and others of about 1500 km. Taking into account the experience of previous expeditions, extensive preparations were made for the complete fulfillment of our assignment. It was decided to prepare three vehicles to be used on the traverse for observations. A malfunctioning "Pingvin" was repaired with the help of the mechanic's shop, and base-line rods for long-range surveying were mounted on the cabin of the heavy tractor.

To ensure uninterrupted food supplies and to save time in the preparation of hot food in the field, precooked frozen food was prepared.

An attempt was made to find a new method for height determination, which would permit "expansion" of the field season.

The wide range of field observations and the need to employ high precision optical theodolites in trigonometric leveling limit the time available for field work in low temperatures. The OT-02 theodolites used by our expedition have non-adjustable cylindrical axes, for which it is difficult to select a suitable frost-resistant lubricant. The TsIATIM-201 lubricant, which was tested in Moscow at a temperature of -50°, proved unsatisfactory in prolonged temperatures below -40°. The rotation of the theodolites became more difficult (though this may also have been due to their transport in the equatorial zone). The level readings on the vertical circle were very shaky, and this also affected the accuracy of the measurements.

These deficiencies made it necessary to investigate the possibility of using geometric leveling. A method used in geometric leveling to report altitudes across broad rivers was tested in Antarctica.

Application of this method in the region of Mirny gave promising results. The rms error in rod readings at a distance of 2600 m was less than ±25 mm. Using an NV level, a triangular polygon measuring on the average 2600 m on a side was closed with an error of only + 14 mm. The same level was used at a distance of 2700 m to determine the difference in height between two reference points close to each other with an error of only 2 mm.

The merits of this method lie in the use of levels to make observations. At low temperatures it is simpler to use levels than high precision optical theodolites (since many field observations are abandoned), and the subsequent data processing is considerably simplified. The group was thus also prepared to make observations by geometric leveling.

A train of sledges and caterpillars left Mirny on 13 September, 1961, and on 15 October delivered some provisions and geodosic instruments to Komsomol'skaya, where a landing strip was prepared. Transfer of the last items of freight, and final equipment of the vehicles was done by airplane. The first observations on the profile were begun on 12 November.

The following geodesic research was envisaged:

1. To ascertain the real accuracy in determination of height above sea level by the method of base line surveying with simultaneous reciprocal measurement of zenith distances from the error in closure of the polygon.

2. To establish the height above sea level of the Antarctic dome from the closed polygon Komsomol'skaya-Sovetskaya-Vostok-Komsomol'skaya.

The technical advice compiled from the experience of the geodesists in the Fourth KAE (S. N. Shcheglov and A. A. Khoman'ko) was used for guidance in making field observations.

The team had three vehicles: Nos. 2 and 4 "Pingvin" all-terrain vehicles and No. 29 ATT tractor, equipped with geodesic instruments designed by S. E. Aleksandrov. The "Pingvins", which were used previously in the Fourth KAE, had six-sided cabins with desks for the theodolites.

An AK-55 astronomical compass and an angle gage were also installed on the main rod pedestal of each "Pingvin." The true course of the vehicle was determined by the astronomic compass and then placed on the pick-up of a GPK-52 gyro semicircumferentor.

In this way the azimuth of the line was determined on every vehicle before starting each 5-kilometer lap of the route, and the straight line course was maintained using gyro semicircumferentors. All these navigation instruments worked well, and in conjunction with the others, ensured a straight line course along the predetermined route, departing from it exactly where necessary to reach the junction stations.

The angle gage was intended to measure the nonperpendicularity of the stadia rod to the sighting ray. This instrument has a horizontal circle with graduations of 2° and a leveling device. The 0° to 180° arc of the horizontal circle was set perpendicular to the rod and a bearing was taken on the snow-going vehicle, after which the angle was measured relative to this line.

The following modus operandi was adopted. The "Pingvin" all-terrain vehicles, without any load (to increase their mobility and speed), were used for observations, while the AAT was employed to carry the freight. On the Sovetskaya-Vostok section, when the load on the AAT was smaller, all three vehicles were used for observations, which made it possible to increase the daily rate from 25-30 to 35-40 km.

The maximum advance along the profile in a single day (60 to 65 km) was achieved when the "Pingvins" followed the old track (on the Vostok-Komsomol'skaya section) from point to point. Each day the vehicles for the measurements on the first link were set up for the next day's observations. Measurements started upon a signal given at a predetermined time. As a rule, observations on a single link lasted less than 45 min. After completion of the measurements, the closing vehicle moved on some 10 km to the next point.

The work done at every intermediate point included:

1) measuring zenith distances immediately after the flags were raised (the signal to begin work). Convergence of the zenith distances and the location of the zenith in the sightings was checked;

2) measuring the angle of parallax with a check on convergence of the angles and magnitudes of the double collimation error;

3) measuring the angle of turn on the rear vehicle and fixing on the front vehicle a surveying rod in line with the direction of the rear one;

4) reading the aneroid barometers and thermometers on both vehicles;

5) measuring the angle of nonperpendicularity of the rod to the sighting ray;

6) lowering the flags — the signal to terminate work on the link, and to move the rear vehicle on to the next point.

While the rear vehicle was moving on to the next point, the forward one was used to level the marks of the horizontal rod to make bench marks, and to make gravimetric, magnetic, and other observations.

Zenith distances were measured by OT-02 theodolites mounted on the roofs of the "Pingvins" and the tractor. On the Sovetskaya-Vostok section, where the tractor was employed, the observations were conducted from a tripod set up directly on the earth. NV levels were used to level markers and bench marks.

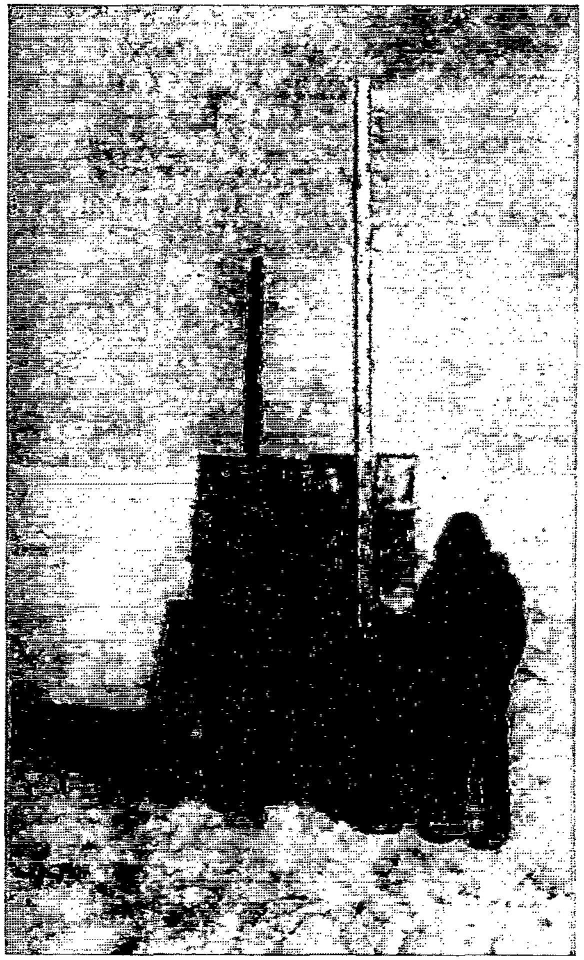
To achieve the required accuracy the zenith distances were measured by two sightings on three cross-hairs or by four sightings on a single cross hair. The differences between the sightings and the variations in location of the zenith did not exceed 15". The errors in measurement of the parallactic angle through convergence in the sightings were less than 5", while the double collimation error did not exceed 8".

The angle of inclination exceeded 3' in only eight cases. Its maximum value, measured on the Sovetskaya-Vostok section, was 13'00" on a side of length 3235 m. The average side length was 5500 m, with minimum and maximum of 2361 and 8566 m, respectively.

Every 50 to 100 km the height was reported on bench marks, for which empty oil barrels were used. 24 bench marks were made on the profile, in addition to four reporting height at Sovetskaya, and five at Vostok. Every bench mark bore a type designation, e.g., IFZ 50 km, BM No. 1.

A table of the height of the bench marks made by the geodesists of the Fourth and Sixth SAE is given at the end of this article.

Control huts were periodically set up at a distance of 50 to 70 m from the vehicles, to check the extent of their sinking in deeper snow. Geometric leveling was done once in the evening, after stopping for the night, and again in the morning before moving to the next point. Usually the sinking was insignificant, but on the Komsomol'skaya-Sovetskaya-Vostok section cases of appreciable snow subsidence over an area of about 9 km^2 were noted. The accompanying rumble seemed especially loud against the background of silence.



Bench mark — two storied Kieselguhr (type 1).

To determine the most suitable part of the day for trigonometric leveling, the accuracy of observations was estimated, and the coefficient of refraction determined. Observations were made at six daily stations.

At first observations were conducted only during the warm part of the day, between 06 and 20 hours, when the temperature was above -50°. At the other stations observations were made round the clock, at 00, 02, 04, 06, 07, 08, 10, 12, 14, 16, 18, 19, 20, and 22 hours.

The results obtained from analysis of these observations show that between 06 and 20 hours the influence of refraction is minimum, making this the most suitable period for trigonometric leveling. The influence of refraction is greatest at night, and the maximum divergence between extremes (12.5 m) was noted at 03 hours on 30 November, 1961, on link 93-94 near Sovetskaya.

The mathematic analysis of the observations by the aerial surveying section of the Soyuzmornii Project, under the direction of B. V. Dubovskii, has been completed. The error in closing the gigantic triangular polygon was + 5.6 m, taking into account the error in the height of the initial point (Komsomol'skaya), of ± 2.7 m, and the rms error of ± 2.9 m in the middle of the line.

In conclusion it can be said that, in spite of severe natural conditions, it is possible to conduct trigonometric (and geometric) leveling in the interior of Antarctic, over extended distances (more than 1500 km), and with a high rate of progress (up to 65 km daily).

Table of bench mark heights

Point	Right angle coordinates		Geographic coordinates		Height, m	Notes
	X, m	X, m	φ, N. lat.	λ, E. long.		
Mirny-2			66°33.4	93° 00.4	50.8	
29			67 10.6	93 27.0	1139.2	BM (barrel)
45			67 25.2	93 35.7	1424.7	BM (barrel)
53			67 39.4	93 46.4	1648.1	BM (barrel)
56			67 43.6	93 45.3	1674.7	147th km
			67 43.6	93 45.3	1674.0	BM No. 2 (barrel)
			67 43.6	93 45.3	1674.6	BM No. 1 (barrel)
			67 43.6	93 45.3	1674.0	BM No. 3 (barrel)
			67 43.6	93 45.3	1676.2	BM No. 4 (wooden pole)
			67 43.6	93 45.3	1674.4	BM (Kieselguhr)
66			67 59.8	93 58.8	1868.4	BM (barrel)
114			69 16.8	94 58.7	2571.1	BM (barrel)
140-			69 44.5	95 31.4	2741.8	BM (barrel with anemometer)
Pionerskaya			69 44.5	95 31.4	2742.0	BM (southern radio mast)
			69 44.5	95 31.4	2741.9	BM (northern radio mast (curved))
			69 44.5	95 31.4	2741.9	BM (low radio mast with curved top)
197			71 44.6	96 24.4	3132.9	BM (Kieselguhr)
207-Vostok-1			72 08.6	96 36.8	3254.8	BM (Kieselguhr, with surveying rod)
207-Vostok-1			72 08.6	96 36.8	3253.2	Large BM (Kieselguhr)
			72 08.6	96 36.8	3252.7	Small BM (three-storeyed Kieselguhr)
220			72 35.9	96 47.0	3332.4	BM (Kieselguhr)
259-Komsomol'-skaya			74 06.5	97 28.0	3500.1	BM (radio mast at the northern corner of the building)

(Continuation of table)

Point	Right angle coordinates X, m	X, m	Geographic coordinates φ, N. lat	λ, E. long.	Height, m	Notes
			74 06.5	97 28.0	3497.8	BM (stay at the northern corner of the building)
			74 06.5	97 28.0	3497.8	BM (radio mast 56 m west of the building)
			74 06.5	97 28.0	3496.9	BM (ATT tractor without caterpillar)
			74 06.5	97 28.0	3496.4	BM (northern corner of the building
			74 06.5	97 28.0	3501.3	BM (Kieselguhr, 4 km south of Komsomol'skaya)
BM No. 1	-8,275,497	17,437,890	74° 31.7'	96° 54.9'	3557.1	I*
BM No. 2	-8,366,723	17,386,687	75 19.2	94 59.6	3677.0	I
BM No. 3	-8,464,724	17,333,219	76 09.2	92 44.9	3703.4	II
BM No. 4	-8,489,195	17,322,655	76 21.6	92 15.1	3698.2	II
BM No. 5	-8,548,757	17,299,347	76 51.9	91 04.3	3662.4	II
BM No. 6	-8,580,609	17,287,816	77 08.0	90 26.4	3666.1	II
BM No. 7	-8,640,879	17,267,148	77 38.2	89 13.1	3641.4	II
BM No. 8	-8,652,113	17,263,786	77 43.9	89 00.0	3642.1	III
BM No. 9	-8,683,171	17,253,740	77 59.3	88 20.9	3649.8	II
BM (Sovet-skaya	-8,730,863	17,243,938	78 43.5	87 32.1	3662.3	IX
BM No. 2 (Sovet-skaya)	-8,730,863	17,243,938	78 23.5	87 32.1	3662.3	X
BM No. 3 (Sovet-skaya)	-8,730,863	17,243,938	78 23.5	87 32.1	3661.6	XI
BM No. 4 (Sovet-skaya)	-8,730,863	17,243,938	78 23.5	87 32.1	3661.3	XII
BM No. 11	-8,728,111	17,349,764	78 30.8	92 13.8	3761.6	I
BM No. 12	-8,727,152	17,398,232	78 32.9	94 24.4	3790.8	II
BM No. 13	-8,726,114	17,457,501	78 34.1	97 04.8	3754.5	I
BM No. 14	-8,724,527	17,521,772	78 33.5	99 59.0	3656.3	II

* Types of bench marks erected by the team of the sixth SEA: I — BM (two-storeyed Kieselguhr); II — BM (barrel); III — BM (one-storeyed Kieselguhr); IV, V, VI, VII — BM (many-storeyed Kieselguhr); VIII — BM (sledge); IX — BM (eastern radio mast); X — BM (bore hole — eastern girder 6 m); XI — BM (nut base of the south-eastern corner of the house); XII — BM (sledge runner — north-eastern corner of the house); XIII — BM (long mast, south-west of the station); XIV — BM (flagstaff near station); XV — BM (mast at the northern end of the station); XVI — BM (north-western corner of the station building); XVII — BM (barrel at the base of the space hut).

(Continuation of table)

Point	Right angle coordinates		Geographic coordinates		Height, m	Notes
	X, m	X, m	φ, N. lat	λ, E. long.		
BM No. 15	-8,723,331	17,592,469	78 31.2	103 09.8	4556.8	II
BM Vostok-1	-8,725,273	16,673,863	78 27.8	106 48.4	3487.9	XIII
BM Vostok-2	-8,725,273	17,673,863	78 27.8	106 48.4	3488.4	XIV
BM Vostok-3	-8,725,273	17,673,863	78 27.8	106 48.4	3489.3	XV
BM Vostok-4	-8,725,273	17,673,863	78 27.8	106 48.4	3489.3	XVI
BM Vostok-5	-8,725,273	17,673,863	78° 27.8'	106° 48.4'	3487.2	XVII
BM No. 16	-8,616,786	17,635,764	77 32.2	104 38.5	3511.2	II
BM No. 17	-8,570,496	17,617,912	77 08.3	103 44.9	3531.8	I
BM No. 19	-8,510,107	17,589,236	76 37.0	102 27.2	3516.1	
BM No. 24	-8,471,828	17,569,814	76 17.0	101 38.2	3551.2	VIII (top of sledge)
BM No. 20	-8,460,980	17,564,535	76 11.3	101 25.3	3558.5	V
BM No. 21	-8,429,729	17,549,722	75 54.8	100 49.8	3556.9	VI
BM No. 22	-8,346,475	17,512,437	75 10.4	99 26.1	3545.7	VII (100km from Mirny)
BM No. 23	-8,271,899	17,478,847	74 30.3	98 17.4	3521.0	VI

It should be noted that all the heights were determined by so-called cantilever extensions. To create a reliable height network and evaluate the accuracy of leveling, it is of the greatest importance to reach the sea — the second bearing point.

Bibliography

1. Shcheglov, S.N. Opredelenie vysot metodom geodezicheskogo nivelirovaniya po marshrutu Mirny-Komsomol'skaya (Height Determination by Geodesic Leveling along the Line Mirny-Komsomol'skaya). — Informatsionnyi Byulletin' SAE No. 28. 1961.

A. P. Kapitsa

THICKNESS OF THE ICE COVER OF THE CENTRAL REGIONS OF EASTERN ANTARCTICA

During 1959 the Fourth SAE (Soviet Antarctic Expedition) measured the thickness of the ice cover along the route Komsomol'skaya-Vostok-South Geographic Pole. Processing of the data obtained for this profile by seismic sounding and gravitational measurements was completed by the end of 1962.

The seismograms obtained by the present author were processed in collaboration with O.G. Sorokhtin (IFZ AN SSSR). The data for measurement of the acceleration due to gravity, obtained between Vostok and the South Geographic Pole by navigator and gravimetrist L.I. Khrushchev, were processed by Yu. N. Avsyuk (IFZ AN SSSR) and myself. For the Komsomol'skaya-Vostok section the data obtained by Avsyuk during the Third SAE were used. After their comparison with my seismic measurements for this section, it was possible to construct a more accurate profile of the ice cover between Komsomol'skaya and Vostok. To construct the ice cover profile between Komsomol'skaya and the South Geographic Pole the data of barometric leveling, obtained during L.I. Khrushchev's traverse and analyzed by the present author to obtain altitudes, were used.

Route and traverse time. A traverse to the South Geographic Pole was scheduled as part of the Fourth SAE in 1959. Seismic sounding of the ice cover, glaciological and meteorological observations were conducted all along the traverse from Komsomol'skaya to the Amundsen-Scott Station (U.S.A.) at the South Geographic Pole. On the section from Vostok to the Pole, gravimetric, magnetic, and gamma- and neutron-logging measurements were also made. The traverse was divided into a number of stages, as follows:

Stage I was preparatory. Between 10 and 26 February, 1959, three heavy "Khar'kovchanka" tractors with the necessary fuel for the traverse to the South Geographic Pole were delivered from Mirny to Komsomol'skaya (a distance of 870 km).

Stage II was also preparatory, and lasted from 27 September to 19 October, 1959. Five medium tractors transported additional fuel and scientific instruments from Mirny to Komsomol'skaya.

Stage III was scientific in character, and lasted from 6 to 29 November, 1959. Three heavy "Khar'kovchanka" tractors and two medium tractors delivered the necessary fuel for the remainder of the traverse from Komsomol'skaya to Vostok (542 km). En route seismic sounding of the ice thickness was performed at four points, and glaciological and meteorological observations were made.

Stage IV was also scientific and extended from 8 to 26 December, 1959. The distance of 1290 km from Vostok to the South Geographic Pole was traversed by two heavy "Khar'kovchanka" tractors and one medium tractor. Seismic sounding was performed at eight points, gravimetric observations at 28, and magnetic at 24 points along the route. Glaciological and meteorological observations and gamma- and neutron-logging were also made.

Stage V, from 29 December, 1959 to 10 January, 1960, repeated only gravimetric observations along the route South Pole-Vostok as a check. The entire traverse gave data on the ice cover section over a profile of 1832 km (Komsomol'skaya-Vostok-South Geographic Pole).

Equipment. For seismosounding a standard portable SS-24-P seismo station with the following modifications was used: (1) the amplifiers had an additional high-frequency filter which cut out oscillations with a frequency below 160 cps; (2) in addition to the station's standard oscillograph, an OS-27 oscillograph with high-frequency galvanometers and a natural frequency of 380 cps was installed; (3) to match the amplifiers of the SS-24-P station and the galvanometers a special matching attachment was built.

These alterations enabled the station to register high-frequency oscillations in the range 160 to 200 cps. Twenty-four SP-16 seismic detectors were placed at intervals of 20 m. For reflected wave sounding the instruments were arranged in a straight line with the detonation point in the center of the profile.

The explosions took place in wells, drilled with URB-1 augers, 35 to 54 m in depth. The weight of the charge varied from 2.5 to 10 kg of TNT, according to the intensity of the reflected waves. The moment of the explosion, noted by a pickup from the fuse, was determined with an error of less than 2 millisec.

At every point of the seismosounding three to ten explosions were made in order to obtain a clear record of the reflected waves. During the entire traverse 50 oscillograms were obtained for twelve months, ten of which gave unambiguously interpretable seismograms. Only two points failed to give reflections.

Noise and inaccuracy of instrumentation. The greatest obstacle to research in the central regions of Antarctica was background noise arising after the explosion. As a result of the multiple superposition of surface waves and their slow damping, and even when it was absent, weak reflection was recorded on the oscillogram, and interfered with the surface waves. O.G. Sorokhtin suggested a new modus operandi, consisting of recording high-frequency waves and obtaining reflection against a quieter background. The indicated modifications of the instrumentation permitted the recording of high-frequency oscillations with low background noise.

Another serious source of interference was the inaccuracy of the equipment, which resulted from the extensive vibration in the body of the machine and the great temperature differential in the compartment where it was located (from -50° to +25° C). Jolting and temperature fluctuation put the suspended galvanometer systems out of order, and since their supply was limited, it was not possible to use all 24 channels of the seismostation by the end of the traverse. It is therefore apparent on the

Soviet Antarctic Expedition

Area Vostok

Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 220

Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 0-420

Q = 5.0 kg

h = 46 m

ϕ - 150 - ∞

5. XII. 59

Soviet Antarctic Expedition

Area South Pole

Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 220

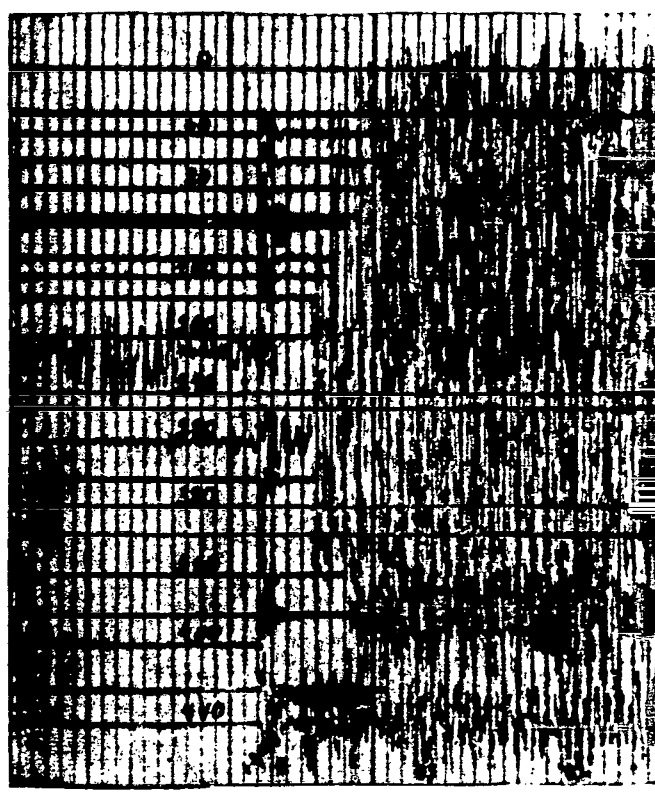
Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 0-460

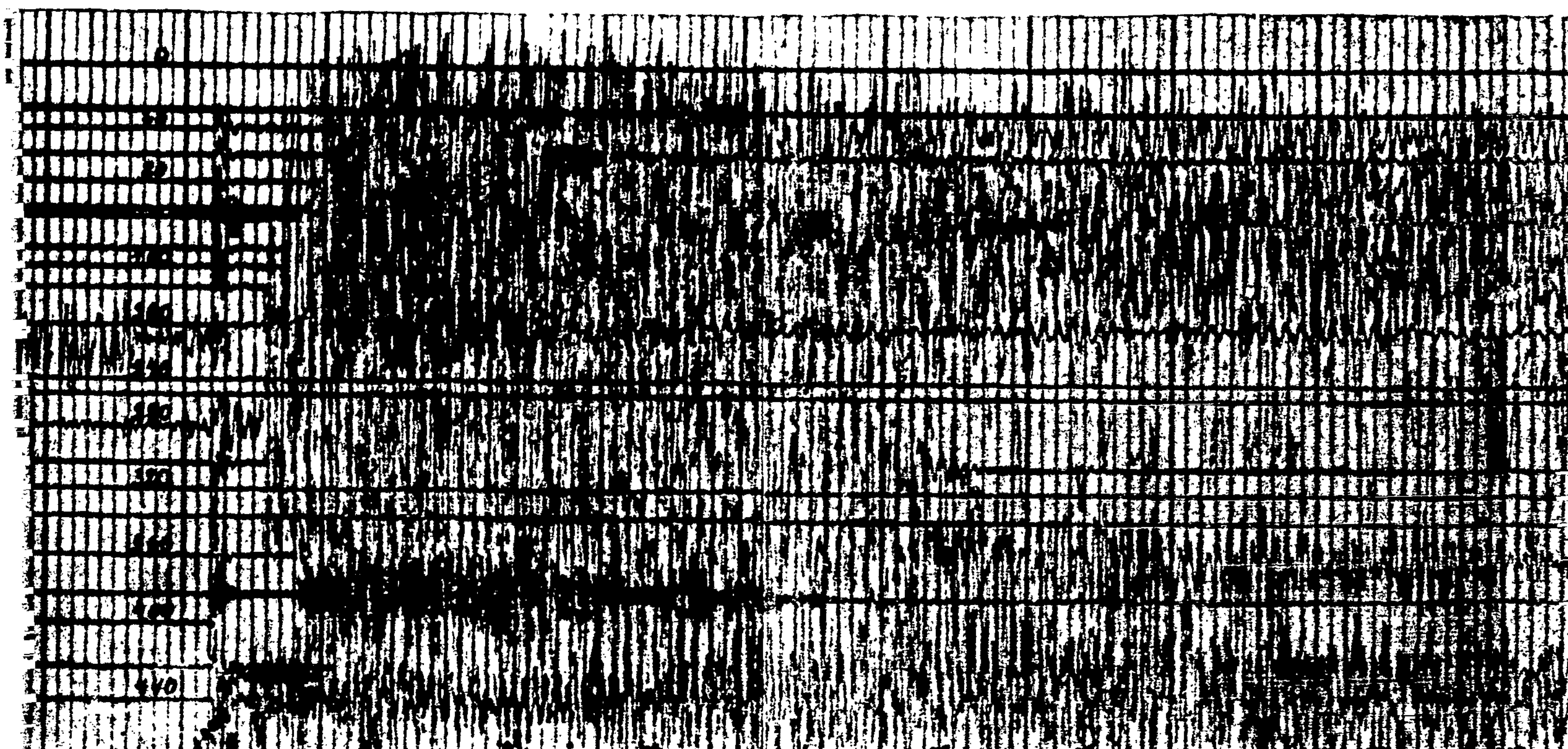
Q = 5.0 kg

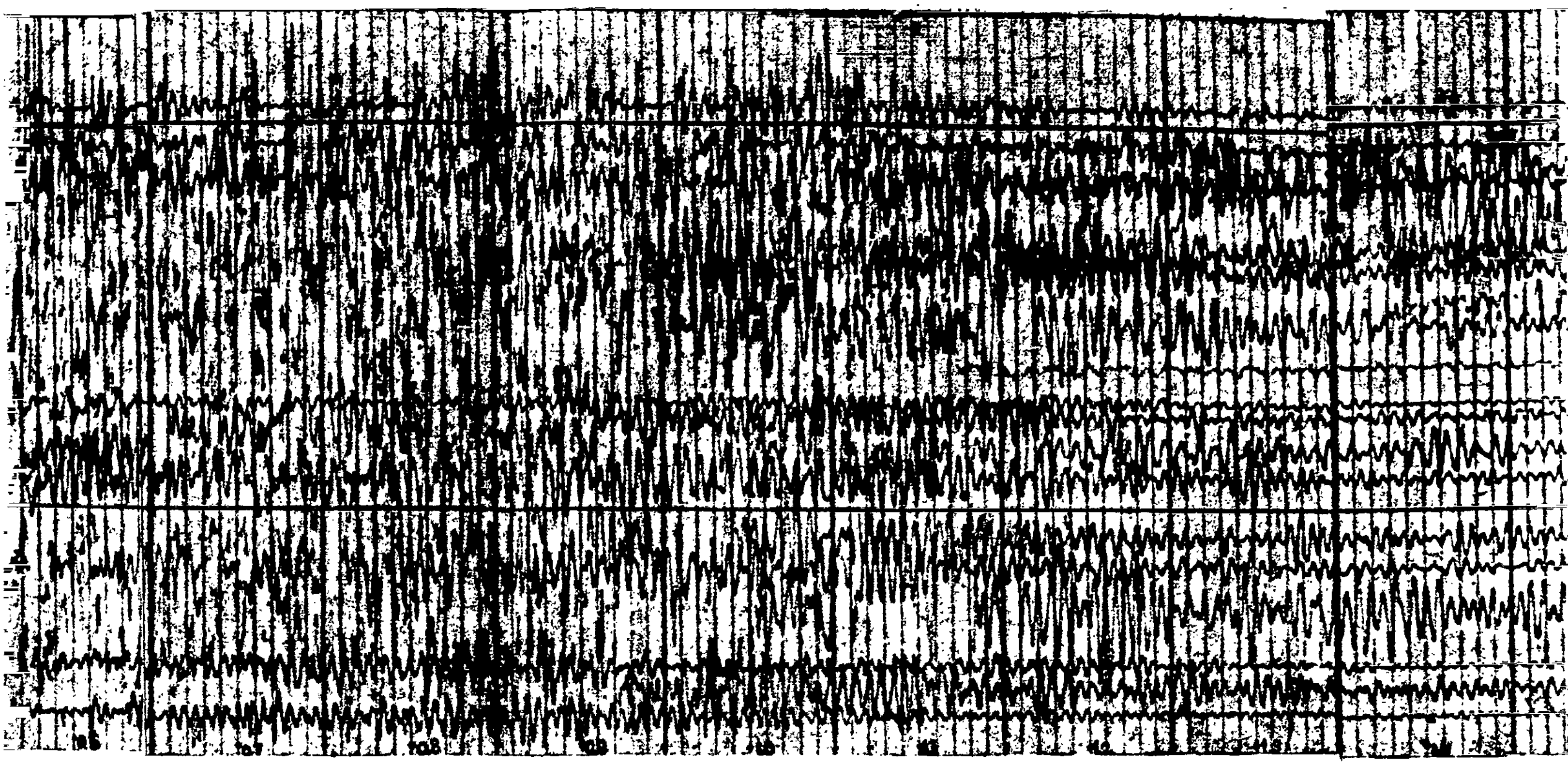
h = 43 m

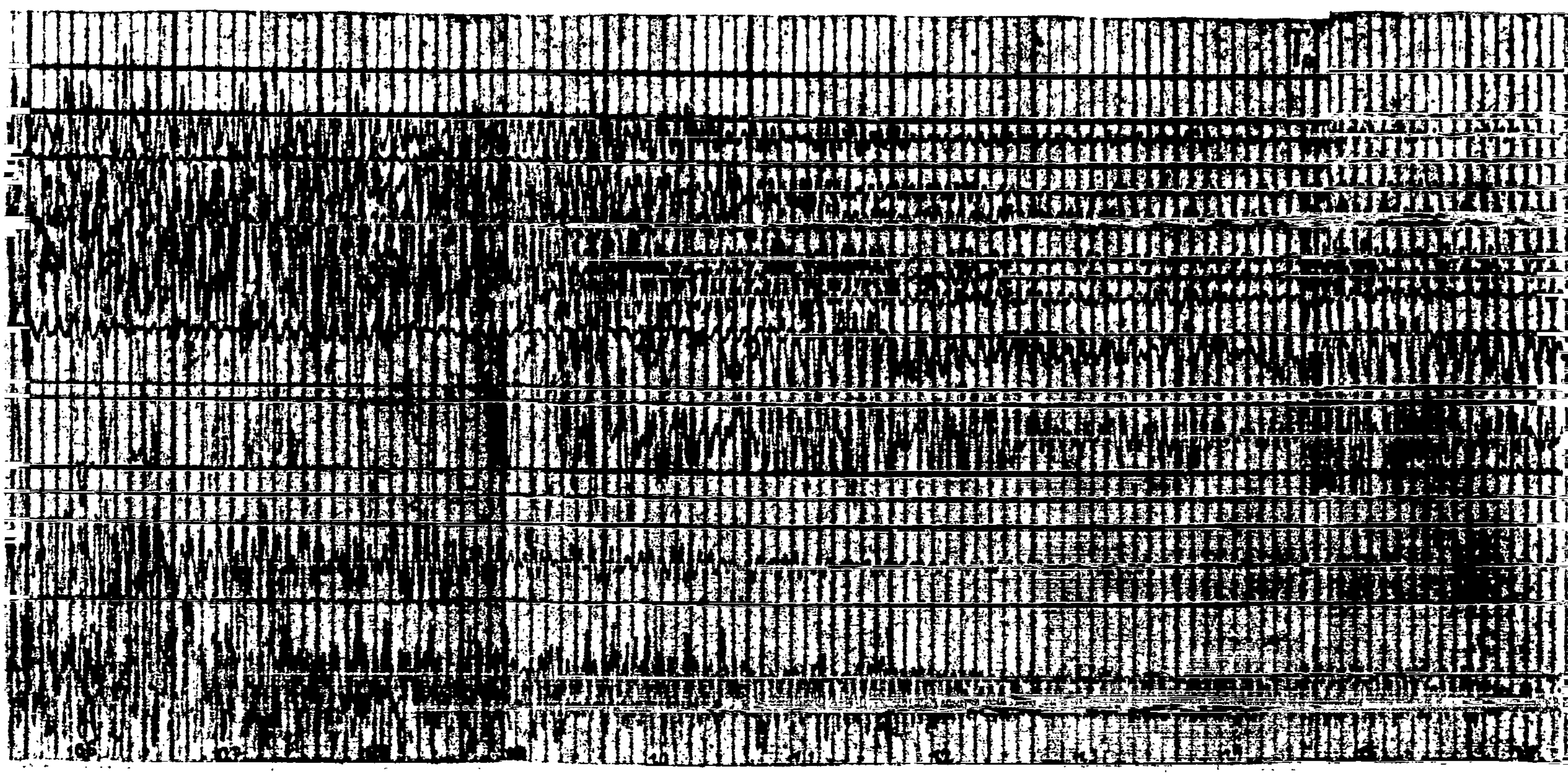
ϕ - 150 - ∞

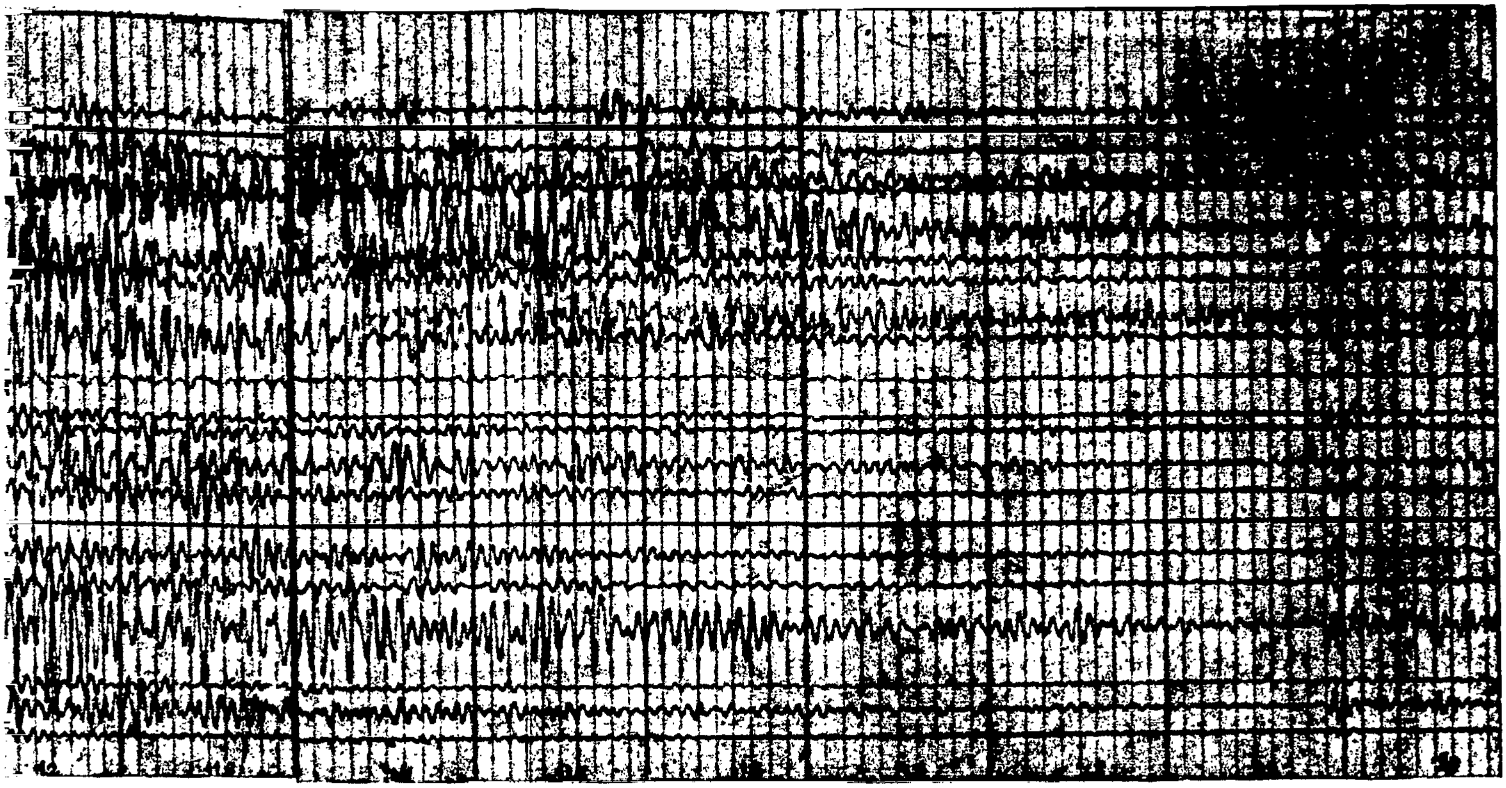
29. XII. 59

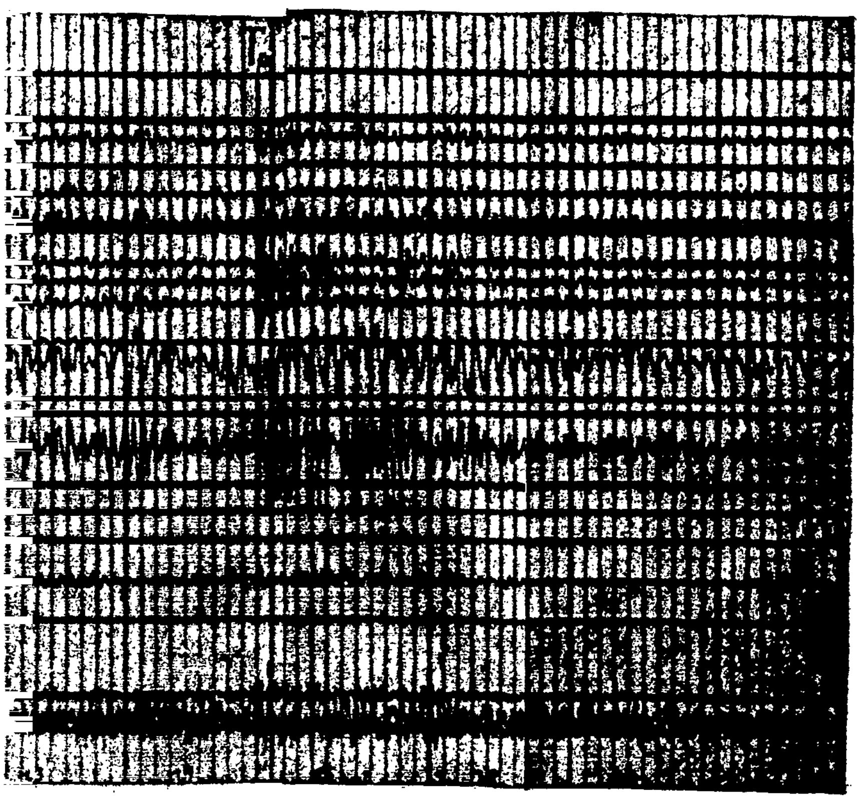












1403 64-65a

Soviet Antarctic Expedition

Area South Pole

Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 220

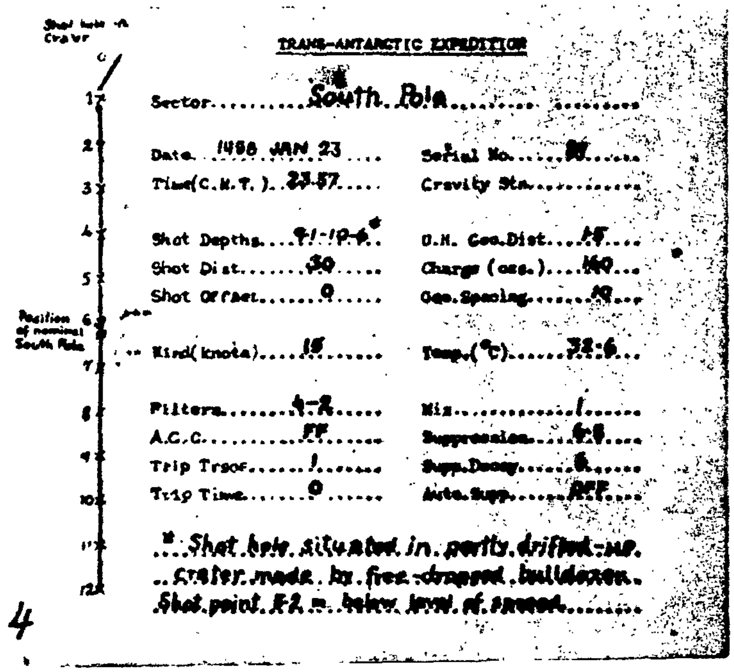
Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 0-460

Q = 10.0 kg

h = 43 m

ϕ - 180 - ∞

29. XII. 59



Shot hole in Crater

TRANS-ANTARCTIC EXPEDITION

Sector.........South Pole.........

Date. 1958 JAN 23.... Serial No......[illegible]......

Time(G.M.T.)..23.57.... Gravity Sta..............

Shot Depths....[illegible]*.. U.H. Geo.Dist....[illegible]....

Shot Dist.......30..... Charge (ozs.)....160...

Shot Offset.......0..... Geo.Spacing.........[illegible]...

Position of nominal South Pole

Wind(knots).....15....... Temp.(°C).......32.6...

Filters.......[illegible]..... Mix...............1.......

A.C.C...........FF....... Suppression......[illegible].....

Trip Trsor......1....... Supp.Decay........6.......

Trip Time.......0....... Auto.Supp........OFF....

*. Shot hole situated in partly drifted-up crater made by free-dropped bulldozer. Shot point [illegible] m. below level of [illegible]........

4

Soviet Antarctic Expedition

Area South Pole

Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 220

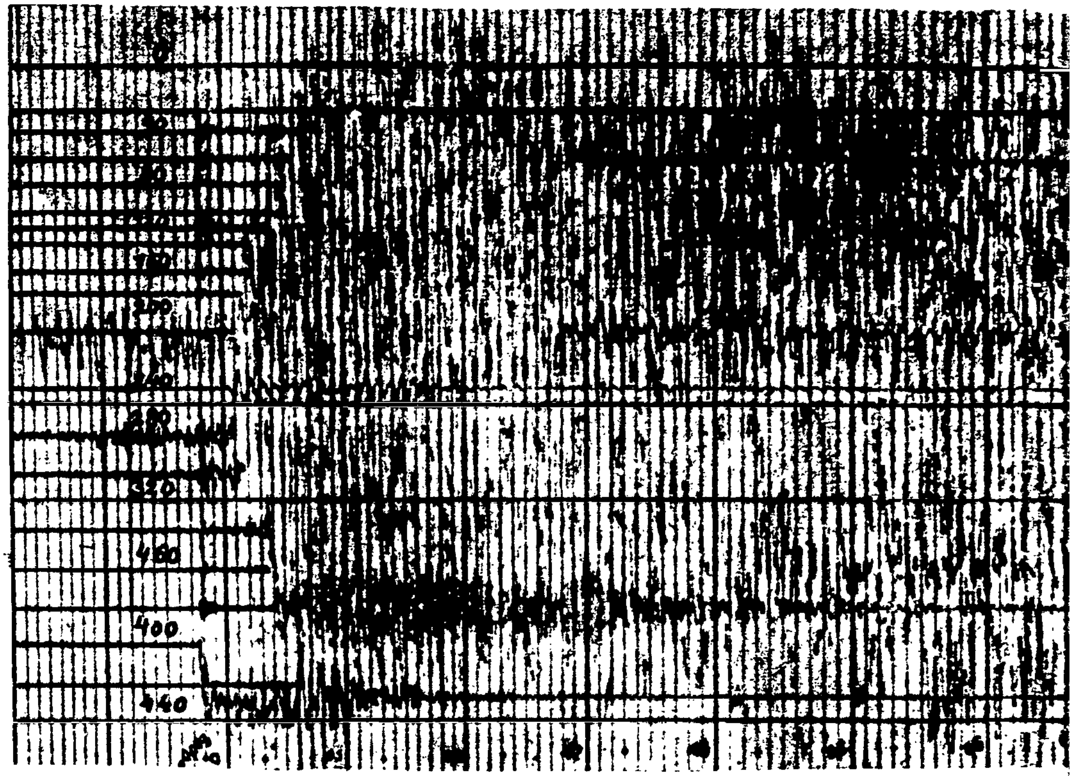
Polar Air, Polar Commission (of the Academy of Sciences of the USSR) 0-460

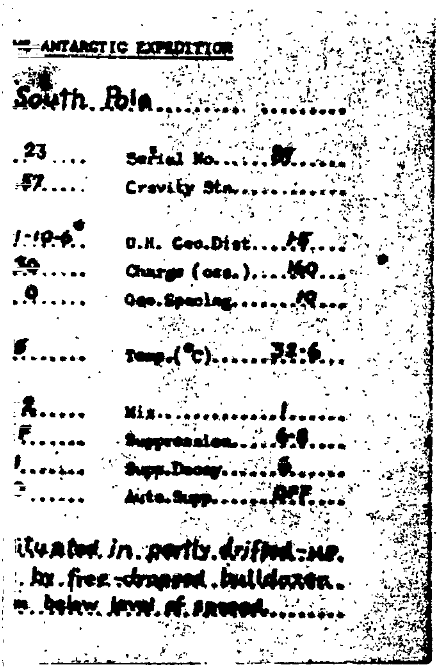
Q = 10.0 kg

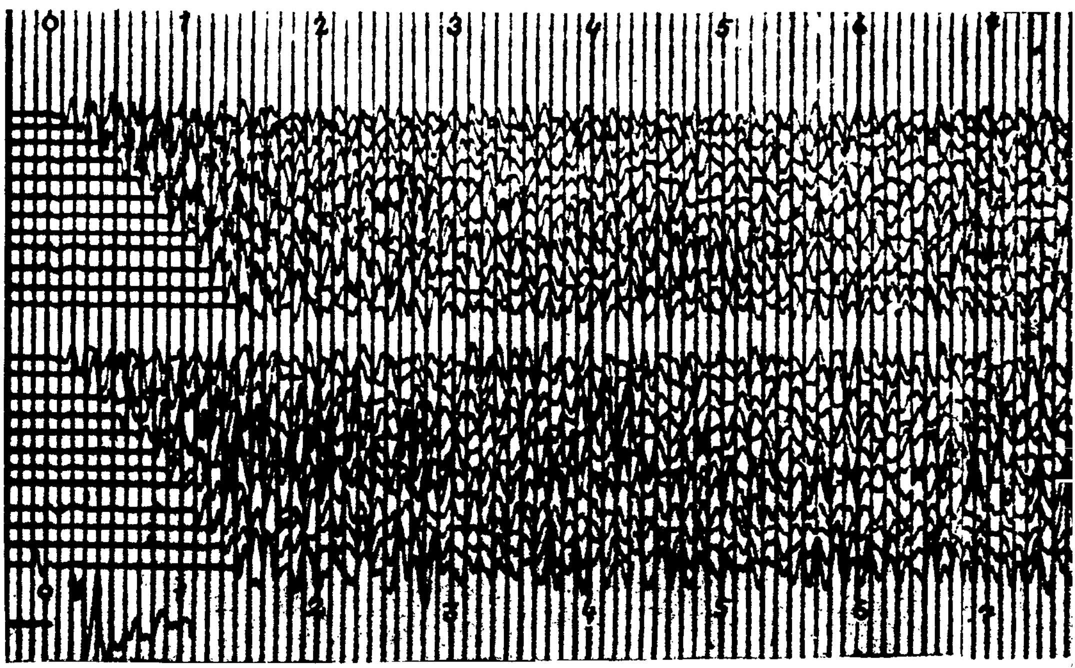
h = 43 m

ϕ - 180 - ∞

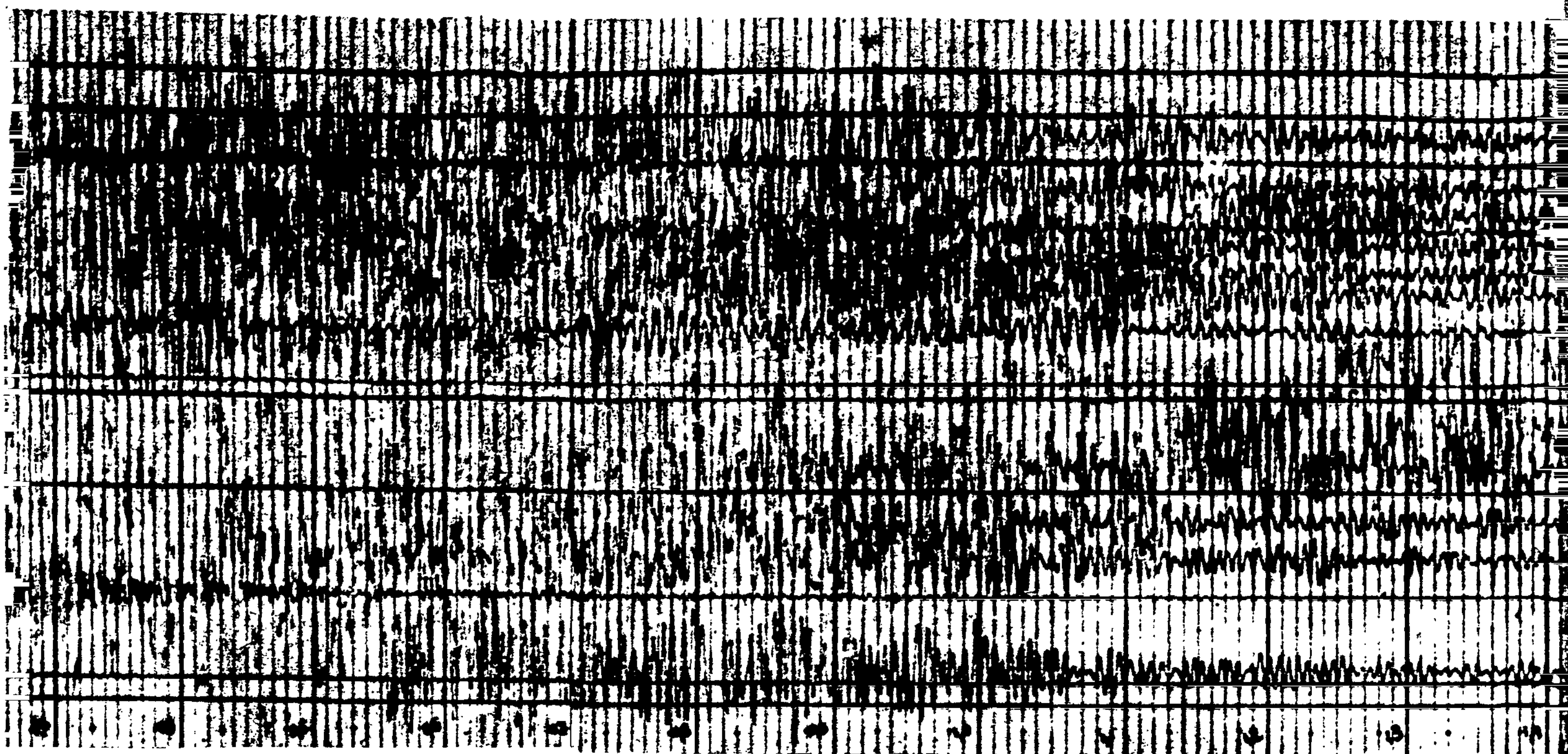
29. XII. 59

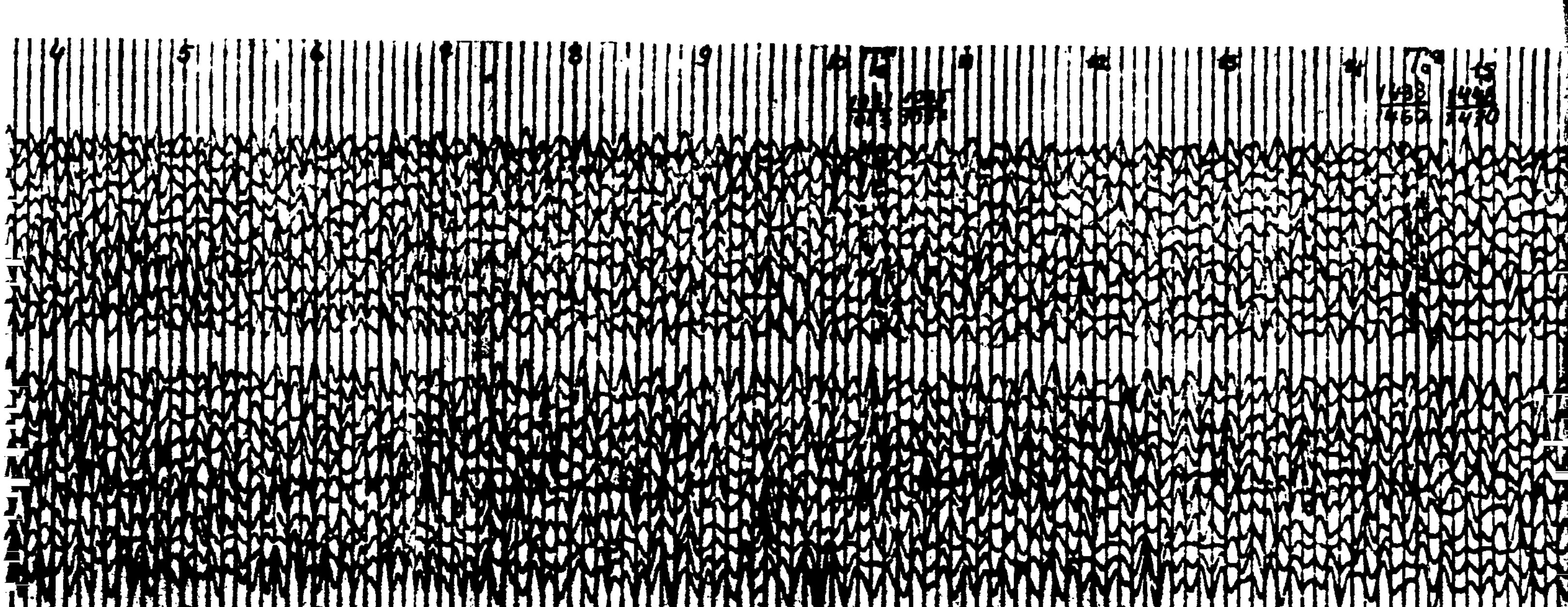




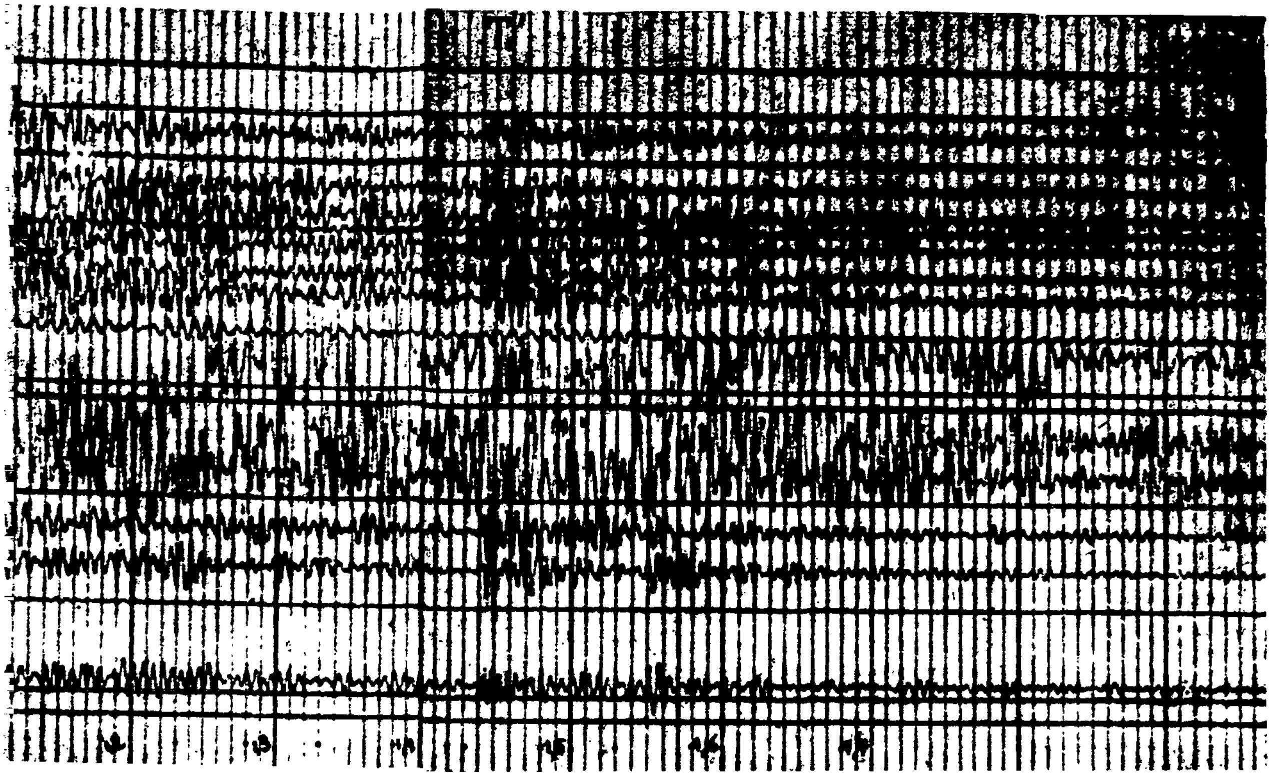


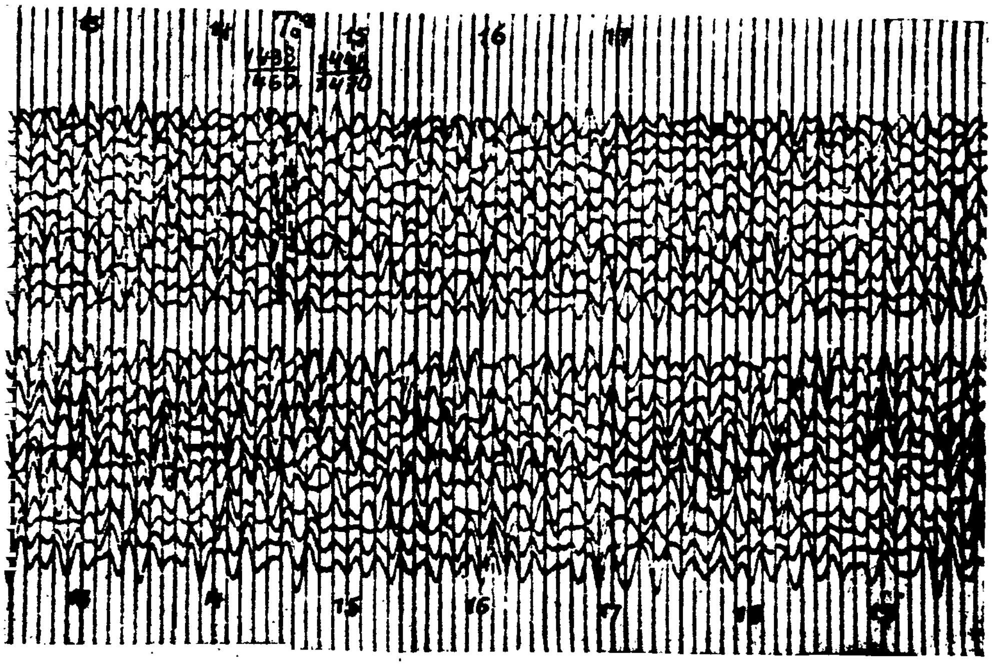
FIGURES 3 and 4





FIGURES 3 and 4





1403 64-65b

seismograms obtained at the South Geographic Pole (see Figures 2 and 3) that eight channels were disconnected. Nonetheless the sixteen remaining gave a sufficiently clear recording of the reflected waves for determination of the thickness of the ice cover.

Analysis of seismograms. Analysis of the seismograms showed the mean velocity of propagation of seismic waves within the ice cover to be 3780 m/sec. This velocity, which was obtained by O.G. Sorokhtin /1/ for the region of Komsomol'skaya, is characteristic of the interior regions of Antarctica, where the thickness of the ice varies between 2000 and 4000 m. The error in determination of the thickness of the ice cover did not exceed 5 %.

The figures show oscillograms obtained by the present author during the traverse.

Figure 1 (inset) shows an oscillogram obtained at Vostok. The reflected wave $T_0{}^1$ was recorded with a comparatively quiet background. At time + 1.94 sec after its first onset the frequency of the reflected wave was 180 to 200 cps. The remaining oscillograms obtained at Vostok also show reflections of $T_0{}^1$, which are correlated as reflections from the boundary of the ice and its bed, and correspond to an ice thickness of 3700 m.

Seismic sounding had been performed previously at Vostok by the Third SAE. At that time the thickness of the ice cover there was found to be 1700 m. Comparison of Sorokhtin's oscillograms from the Third SAE with those obtained by the Fourth SAE showed that $T_0{}^1$ reflection was also scanned on the oscillograms of the earlier expedition, but the reflection interpreted as corresponding to a thickness of 1700 m was found to be erroneous.

Figures 2 and 3 (inset) show oscillograms obtained at the South Geographic Pole. The group of reflected waves at 1.46 sec after their first onset were unambiguously correlated on all the oscillograms as reflection from the boundary of the ice and its bed, and corresponding to an ice cover thickness of 2810 m. Until now the figure of 1990 m, determined by D. Pratt at the time of the British Commonwealth Trans-antarctic Expedition led by V. Fuchs, was accepted in the literature/2/.

Figure 4 (inset) shows an oscillogram obtained by Pratt at the South Geographic Pole on 23 January, 1958, and published in the expedition report. On it two waves, at the moments 1.021 sec ($T_0{}^1$) and 1.438 sec ($T_0{}^2$) are distinguished. Pratt remarks that the true wave reflected from the ice bed is the $T_0{}^1$ wave, which corresponds to an ice thickness of 1990 m.

Analysis of this oscillogram shows that although the oscillation amplitude of the reflected wave does not exceed that of the background noise, the waves cannot be distinguished with certainty. The oscilllogram was recorded through the explosion of a 4 kg TNT charge at a depth of 5.2 m. The wide frequency characteristic in recording, which corresponds to the experience of Soviet researchers, indicates that Pratt could not have obtained a clear recording of the reflected wave. For comparison here are the circumstances under which the oscillograms in Figures 2 and 3, also obtained at the South Geographic Pole, were recorded: explosion depth 43 m, charge 5 and 10 kg TNT, filtration cutoff of oscillations below 150 cps. In spite of the rather high background noise, the amplitude of the reflected wave was five or six times that of the background noise.

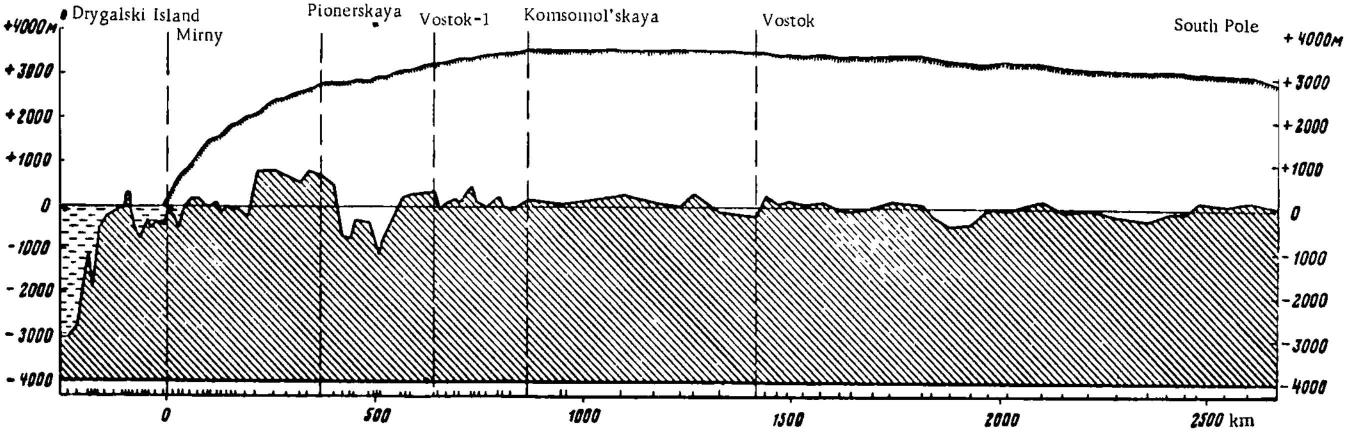
The determinations made by the American expedition in 1960-1961 at the South Geographic Pole practically coincide with the Soviet results as is confirmed by the oscillograms in Figures 2 and 3.

Analysis of the seismic and gravimetric data of the traverse permitted compilation of a table of the thicknesses and heights of the ice cover (Table 1).

TABLE 1. Thickness of the ice cover along the profile Komsomol'skaya-Vostok-South Pole

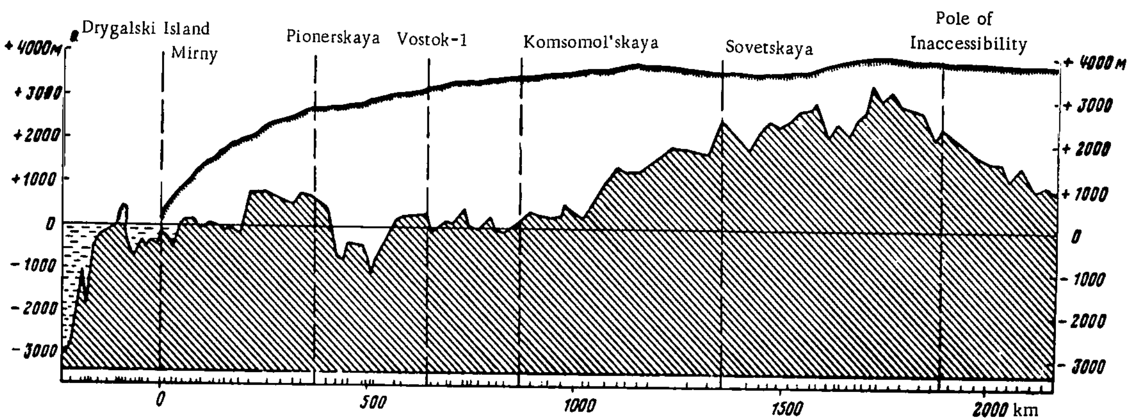
Point No.	Point coordinates: east longitude	Point coordinates: south latitude	Altitude above sea level, m	Ice thickness, m	Bottom mark referred to bed, m from sea level	Means of determination
			Komsomol'skaya			
1	74°05'	97°09'	3490	3360	+130	Seismic
2	74 48	98 20	3500	3450	+ 50	"
3	74 52	98 46	3510	3430	+ 80	Gravimetric
4	75 56	100 36	3530	3300	+230	Seismic
5	76 38	101 36	3500	3410	+ 90	Gravimetric
6	77 03	102 45	3500	3480	+ 20	"
7	77 18	103 32	3510	3220	+290	Seismic
8	77 49	104 47	3500	3610	-110	Gravimetric
			Vostok			
9	78 27	106 52	3490	3700	-210	Seismic
10	78 39	106 52	3500	3250	+250	Gravimetric
11	78 54	106 52	3430	3370	+ 60	"
12	79 08	106 52	3430	3300	+130	"
13	79 28	106 52	3400	3350	+ 50	"
14	79 49	106 52	3400	3450	- 50	"
15	80 13	106 52	3380	3440	- 60	Seismo-gravimetric
16	80 28	106 52	3390	3480	- 90	Gravimetric
17	80 54	106 52	3420	3450	- 30	"
18	81 16	106 52	3440	3340	+100	"
19	81 58	106 52	3460	3410	+ 50	Seismo-gravimetric
20	82 10	106 52	3390	3580	-190	Gravimetric
21	82 34	106 52	3320	3750	-430	"
22	83 01	106 52	3300	3660	-360	"
23	83 24	106 52	3280	3290	- 10	"
24	83 50	106 52	3300	3340	- 40	Seismic
25	84 35	106 52	3280	3130	+150	Gravimetric
26	85 02	106 52	3210	3310	-100	"
27	85 36	106 52	3150	3200	- 50	Seismic
28	86 13	106 52	3120	3310	-190	Gravimetric
29	86 54	106 52	3110	3380	-270	"
30	87 18	106 52	3100	3210	-110	"
31	87 14	106 52	3090	3150	- 60	Seismic
32	87 58	106 52	3080	2930	+150	Gravimetric
33	88 36	106 52	3060	2950	+110	"
34	89 06	106 52	3020	2840	+180	Seismic
			South Pole			
35	89 59	30 00	2860	2810	+ 50	Seismic

A section of the interior of the ice cover along the profile Mirny — Komsomol'skaya — Vostok — South Pole (Figure 5) was constructed from the data of Table 1 and of the Third SAE. A section of the ice cover, obtained by the Third SAE along the profile Mirny — Komsomol'skaya — Pole of Relative Inaccessibility /1/ is reproduced in Figure 6. Analysis



Drygalski Island
Mirny
Pionerskaya
Vostok-1
Komsomol'skaya
Vostok
South Pole
+4000м
+3000
+2000
+1000
0
-1000
-2000
-3000
-4000
0
500
1000
1500
2000
2500 km

FIGURE 5.



Drygalski Island
Mirny
Pionerskaya
Vostok-1
Komsomol'skaya
Sovetskaya
Pole of
Inaccessibility
+4000м
+3000
+2000
+1000
0
-1000
-2000
-3000
0
500
1000
1500
2000 km

of both profiles shows that the subglacial relief of Antarctica has a very complicated character. Although great mountain masses with altitudes as much as 3000 m above sea level were discovered on the profile to the Pole of Relative Inaccessibility and lowlands descending to 1100 m below sea level in the region to the south of Pionerskaya, the bed between Komsomol'skaya and the South Geographic Pole has a smoother and flatter character. Here the maximum altitude is 290 m above sea level, and the maximum depth of the bed is 430 m below sea level. The ice cover surface reaches its maximum altitude between Vostok and Komsomol'skaya (3530 m above sea level). It should be noted that the ice thickness at this point is 3300 m, i.e., the uplift above the surface of the ice cover is not related to the elevation of the subglacial bed, as is evident from the profile to the Pole of Relative Inaccessibility. Here the highest point on the surface corresponds to the highest point of the subglacial bed, and the ice thickness at this point to 750 m.

On the profile Komsomol'skaya — South Geographic Pole almost no indications of the mountain range discovered by the Third SAE are visible. Only small elevations of the order of 250 to 300 m and a hollow some 250 m in depth in the region of Vostok can be considered spurs of this mountain mass. Taking into account the 30° bend in the profile near Vostok, it can be assumed that these elevations of roughly the same height and width are the same ridge, twice intersected by the profile. A single profile is of course inadequate to give a picture of the subglacial bed of the entire eastern part Eastern Antarctica, but it can already be assumed, on the basis of existing data on the hypsometry of Eastern Antarctica and sections of the ice cover, that the subglacial bed of the sector of Eastern Antarctica, lying to the east of the meridian of Komsomol'skaya as far as Victoria Land, has a comparatively even character with altitude close to sea level. This point of view is supported by preliminary data on the measurements performed by American expeditions in this region.

The present author has computed the median altitude and ice cover thickness along the profile Komsomol'skaya — South Pole. For this purpose the existing data /1/ for the profile Mirny — Pole of Relative Inaccessibility were used. The following table (Table 2) was compiled from the calculations.

TABLE 2

Observation profiles	Mean altitude of surface above sea level, m	Mean thickness of ice cover, m	Mean altitude of bed above sea level, m
Mirny — Pole of Relative Inaccessibility	3000	2200	800
Komsomol'skaya — South Pole	3340	3330	10
Mean of both profiles	3160	2730	340

As the table shows, the mean thicknesses on both profiles differ by more than 30 %, while the altitudes differ by no more than 10 %.

This figure can be used as a basis for calculations which make it possible to view several aspects of quaternary glaciation in a different light. Taking the mean ice cover thickness of all of Antarctica as 2000 m, the volume of the ice cover can be computed.

During the past few years many papers devoted to isostatic sagging of the crust under the weight of the Antarctic ice cover have appeared /3, 4/. They are confirmed by a number of geophysical data. The mean magnitude of the sag is defined as a third of the thickness of the ice cover, that is, the surface of the original bed of the Antarctic continent lies on the average 800 m below the surface of the ice. Isostatic sagging therefore entails shifting of the substance beneath the crust from the region of subsidence to a place where there is a compensatory elevation of the earth's crust. The ring mountains encircling the Antarctic mainland — Queen Maud Land, Queen Victoria Land, and others — are thought to be such regions of compensatory elevation. There is no question that the elevation of the original bed in the region of these mountains, although connected with the compensatory elevation, cannot fully assure the necessary space for shifting beneath the crust.

Approximate calculation shows that the volume of these mountain massifs, even if it is assumed that their emergence is entirely due to compensatory elevations, does not constitute even 5% of the total volume of the ice and, correspondingly, not more than 15% of the volume of the shifted matter beneath the crust. Even taking into account the degree of approximation of this calculation, it is clear that compensatory elevation takes place beyond the boundaries of the continent, i.e., on the ocean floor. The annular structure of the subacqueous elevations of the floor of the ocean surrounding Antarctica testifies to the legitimacy of such a conclusion, especially if it is taken into account that the thickness of the earth's crust is less here and that it readily yields to deformation. The inevitable shifting of the matter beneath the crust and the concurrent elevation of the ocean floor produce a change in the volume of the total ocean "bowl", which in turn leads to a rise in the level of the ocean. The change in fluctuation of the ocean level can be roughly evaluated as an increase of its volume by 8000 km^3, which would raise it 22 m.

At the same time the thickness and volume of the ice cover are increased by water collected from the World Ocean, which entails eustatic lowering of its level.

Since this process is connected with the prolonged processes of shifting of viscous masses, fluctuations of the ocean level will not coincide in time with the phases of the fluctuation in mass of the ice cover.

At present there are no data on the magnitude of this displacement, but proceeding from the analysis of two wave pictures, it can be assumed that both addition and subtraction of phases take place. Phase coincidence can lead to a much greater rise in the ocean level than isolated volume fluctuation of the World Ocean through melting of the ice or isostasy, while a small rise occurs if the fluctuations are antiphased.

The extreme limits of this process can even now be predicted. The maximum possible rise of the ocean above the present level, in the case of phase coincidence, will be $66 + 22 = 88$ m, and in the case of non-coincidence, $66 - 22 = 44$ m, i.e., taking into account only Antarctic glaciation, the fluctuations in the level of the World Ocean can be appreciable.

It should not be forgotten that similar processes have also occurred in the northern hemisphere. Depending on whether or not they occurred synchronously, they might coincide with variations in the Antarctic ice cap, which would lead to still greater fluctuations in the level of the World Ocean.

I find it necessary to dwell in such detail upon this question because such relationships and laws are often neglected in calculation of fluctuations in the level of the World Ocean.

The immense thickness of the ice cover in the central regions of Antarctica and the corresponding hypothesis advanced by me in 1957 /5, 6/ once more support the possibility that there is a stratum of water beneath the ice cover. I.A. Zotikov's paper on the thermal cycle of the ice cover, which appeared in 1961, also supports this idea. The presence of a water stratum in the bottom regions of the glacier would give a completely new solution of the problem of the expended part of the balance of the central part of the ice cover. As the ice cover melts underneath the water will be forced to the peripheral zones, where it will freeze from below because of the reduced thickness of the ice cover. If there are deep hollows in the meridional trend, it will run into the sea. In the future it will therefore be necessary to measure the salinity of the sea water in the immediate vicinity of the presumed outlets of this water (Mertz and Denman glaciers, Olaf-Pruds Bay, etc.). The presence of distillation in the sea water would be a convincing fact in support of this theory.

By now the eastern part of the eastern Antarctica has been relatively well studied. The itineraries of the Soviet, American, British, and French expeditions have furnished data for the construction of maps of the subglacial bed of this part of Antarctica. Study of the western part of eastern Antarctica, however, has been slight. Aside from the materials gathered by the British Transantarctic Expedition, which passed along the border of this gigantic territory, there are no data at all. During the next few years efforts must be made to direct the attention of government expeditions working in this region toward liquidation of the last great "white spot" of Antarctica whose study may make it possible to draw a map of the subglacial relief of the entire continent.

Bibliography

1. Sorokhtin, O.G., Yu.N. Avsyuk, and V.I. Koptev. Rezul'taty opredeleniya moshchnosti lednikovogo pokrova v Vostochnoi Antarktide (Determinations of the Thickness of the Ice Cover in Eastern Antarctica). Inform. Bull. SAE, No.11. 1959.
2. Pratt, G. Seismic Soundings Across Antarctica. Trans-Antarctic Expedition 1955-1958. Scientific Report, No.3. London, Trans-Antarctic Expedition Committee. 1960.
3. Voronov, P.S. O proyavlenii izostazii v predelakh Grenlandii i Antarktidy (The Occurrence of Isostasy Between Greenland and Antarctica). Inform. Bull. Inst. Geology of the Arctic, No.9. 1958.
4. Ushakov, S.A. and G.E. Lazarev. Ob izostaticheskom progibanii zemnoi kory v Antarktide pod tyazhest'yu ledovoi nagruzki (The Isostatic Sagging of the Earth's Crust in the Antarctic under the Weight of the Ice). Dokl. AN SSSR, 129, No.4. 1959.
5. Kapitsa, A.P. Dinamika kraevoi chasti lednikovogo pokrova Vostochnoi Antarktidy v raione rabot Pervoi KAE AN SSSR 1956-1957 gg (Dynamics of the Border of the East Antarctic Ice Cover in the

Region Studied by the First SAE AS SSSR in 1956-1957). Moscow State University, Faculty of Geography. 1958 (author's abstract).

6. Kapitsa, A.P. Dinamika i morfologiya lednikovogo pokrova tsentral'nogo sektora Vostochnoi Antarktidy (Dynamics and Morphology of the Ice Cover in the Central Part of East Antarctica). Trudy SAE, 18. Leningrad, Izdatel'stvo "Vodnyi Transport". 1961.
7. Zotikov, I.A. Teplovoi rezhim lednika Tsentral'noi Antarktidy (Thermal Cycle of the Central Antarctic Glacier). Inform. Bull. SAE, No.28. 1961.

G. P. Dubinskii

METEOROLOGICAL STUDY IN MOUNTAINOUS REGIONS OF THE USSR SHOULD BE CONTINUED

The Department of Physical Geography and Cartography of Khar'kov University im. A.M. Gor'kii has since 1957 been conducting meteorological studies in the mountains of the Caucasus for the IGY.

Two international reference points for detailed study of the meteorological conditions and cycles of the Caucasus glaciers were found. These are the station on the Bashkar glaciers (in the Baksan ravine) and at Alibek (in the Teberda preserve), where more or less steady observations were made during the summer. Similar observations were organized on the glaciers of Karaugom, Tsei (the northern slope of the Great Caucasus), and Gul' (Svanetia). Three to five reference points were established on the reference glaciers: on snowflakes, on ice, on the surface moraine, and beyond any possible influence of the glacier. On Bashkar Glacier, for example, four such points, one of which was located on the "green inn", i.e., beyond the influence of the glacier, were used throughout the IGY. At all points the temperature of the active surface, albedo of the underlying surface, and weather were observed. Actinometric observations were also made (the intensity of direct and transverse radiation was measured by an albedometer with a galvanometer). Points at altitudes of 20, 50, 150, and 200 cm above the surface of the earth were chosen for gradient observations.

At some stations automatic recorders (thermograph and hygrograph) were used to measure sediment and the flow of water in the limiting glacial aligning stream.

The meteorological observations on Bashkar, Karaugom, and Tsei glaciers during the IGY were made at approximately the same place as during the Second IPY (International Polar Year). These observations are of considerable interest, since their results can be compared with existing data on the glaciers. In particular, a preliminary comparison of the data of the second IPY and those of the IGY shows that Alibek Glacier, the largest in the western Caucasus, is now gradually, but quite rapidly, retreating at about 10 m per year.

During the IGY summer some 20 to 25 observation points on the Caucasus glaciers were in operation. The radiation balance of the glaciers and their microclimate were observed.

At present the generalization of the collected data is nearing its conclusion. Some results of the observations and a brief extension of them are to be found in "Data of the Caucasus Expedition" (Materialakh Kavkazskoi ekspeditsii) /1/. IGY observations were continued during the summers of 1961 and 1962. The lack of winter bases made it impossible to complete a year-round cycle of observations.

Meteorological observations in mountainous regions should be continued, and the existing network of observation points enlarged, with observations conducted the whole year round. The organization of observations in connection with the cooling expected during the IQSY, and in particular, the creation of a year-round base on Alibek and Bashkar Glaciers is especially important. A single control center for mountain meteorology should be established in the Geographical Institute of the Academy of Sciences of the USSR so that systematic meteorological study in mountain regions can be undertaken.

Bibliography

1. Materialy Kavkazskoi ekspeditsii (po programme MGG (Data of the IGY Caucasus Expedition). Izd. Khar'kovskogo yniversiteta, 1. 1960: 2. 1961; 3. 1961; 4. 1962.

Yu. A. Meshcheryakov

THE FIRST INTERNATIONAL SYMPOSIUM ON RECENT CRUSTAL MOVEMENTS

At the Twelfth General Meeting of the International Geodesic and Geophysical Union in Helsinki a permanent Commission for the Study of Recent Crustal Movements was formed within the International Association of Geodesy at the suggestion of the Soviet delegation. At present the Commission includes representatives of 29 countries participating in the IGGU. Its president is Yu. A. Meshcheryakov, and its Secretary, S. Miyamura, of Japan.

At the same time as it was decided to set up this commission a decision was also made to hold an international symposium on recent crustal movements during the period between the Twelfth and Thirteenth Meetings of the IGGU. With the agreement of the East German Academy of Sciences in Berlin, the symposium was held from 21 to 26 May, 1962, in Leipzig. The Chairman of the Organizing Committee was O. Meisser (East German Academy of Sciences), and its other members, Yu.D. Bulanzhe and Yu.A. Meshcheryakov (USSR), and S. Miyamura (Japan).

The symposium was preceded by a great deal of preparatory work. In addition to invitations to participate in the symposium, the text of a program of international cooperation in the study of recent crustal movements was sent out. This program, developed by Yu.D. Bulanzhe and Yu.A. Meshcheryakov, was approved by Soviet experts at a conference on the subject, held in Moscow in November, 1961. The Organizing Committee received many remarks and additions to this program, which subsequently greatly facilitated making the corresponding resolutions. The texts of the papers were printed and distributed to the participants. Thanks to the efforts of Professor O. Meisser and his colleagues the symposium was held in most agreeable conditions.

About 100 scientists from Austria, England, Bulgaria, Hungary, East Germany, Denmark, Italy, Poland, Southern Rhodesia, Roumania, the USSR, Finland, France, West Germany, Czechoslovakia, Switzerland, Sweden, Norway, and Japan participated in the symposium. Among them were: J. Levalois (France), General Secretary of the International Association of Geodesy; Professor T. Sorgenfrei (Denmark), General Secretary of the International Geological Union; R. Tomaschek (West Germany), President of the Permanent Commission for Study of (the Earth's Tides; Professor T. Kukkamyaki (Finland), Chairman of the Section for Precise Leveling of the International Association of Geodesy; Professor L. Egyed (Hungary); Professor L. Asplund (Norway); Dr. S. Kryński (Poland); Professor M. Odlanicki (Poland); Professor C. Morelli (Italy); Professor E. Nisimura (Japan); Professor A. Zátopek (Czechoslovakia), and other well known experts. The Soviet delegation, headed by Professor Yu.D. Bulanzhe, included: L.B. Aristarkhova,

• Geophysical bulletin, No. 12. 1962.

N.V. Dumitrashko, S.K. Gorelov, M.K. Grave, A.A. Izotov, P.P. Kazanchyan, Yu.B. Kaz'min, M.V. Karandeeva, A.V. Kondrashkov, Yu.S. Kochetkov, L.A. Latynina, I.P. Lesis, V.A. Magnitskii, E.I. Magnitskaya, A.M. Marinich, Yu.A. Meshcheryakov, G.D. Panasenko, A.K. Pevnev, V.A. Rastvorova, A.P. Rozhdestvenskii, L.N. Rykunov, L.E. Setunskaya, P.F. Shokin, V.P. Shcheglov, and S.N. Shcheglov.

The symposium opened on 22 May, 1962 in the ancient town hall of Leipzig. Professor O. Meisser read out the greetings of Professor V. Hartke, President of the East German Academy of Sciences in Berlin, and Honorary Chairman of the symposium. Yu.D. Bulanzhe, Vice-President of the International Association of Geodesy, made a speech of greeting, and Yu.A. Meshcheryakov devoted his first words to the fundamental problems of study of recent crustal movements.

The proceedings of the symposium took place at Markkliberg, a picturesque Leipzig suburb. Sixty-two papers, grouped according to subject matter, were heard and discussed. At the sessions there was simultaneous translation into English, German, Russian, and French.

Yu.D. Bulanzhe delivered a paper on the subject, "General Questions and Problems of the Commission for Study of Recent Crustal Movements"; Yu.A. Meshcherkov, on "Some Additions to the Program for International Study of Recent Crustal Movements"; and T. Kukkamyaki, on "Problems of the Commission for Study of Crustal Movements".

Papers of a methodological and regional character were given on the subject, "Geodesic Problems in Study of Recent Crustal Movements". P.S. Sakatov (Moscow) read a paper on "Application of the Method of Repeated Leveling to Study of Recent Crustal Movements". The papers of E. Newerowski and T. Wyźykowski (Poland), I. Boehm (Czechoslovakia), and A. Germanowski (Poland) were devoted to methods of determining vertical crustal movement. A.A. Izotov considered geodesic methods for determining horizontal crustal deformation, while L. Hradilek (Czechoslovakia) proposed a new means for determination of crustal deformation in mountainous regions. The paper of L.E. Setunskaya, E.A. Fin'ko and Z.I. Martynova was devoted to methods for geological and engineering survey of repeated leveling lines to reveal nonstructural displacements of individual unstable marks.

L. Kmordi (Hungary) and B. Kris (Czechoslovakia) reported on study of crustal movement in their respective countries. O. Simonsen (Denmark) demonstrated a new map of recent vertical movements in Denmark, and M. Tepertser (Austria) presented data on recent crustal movements in Austria. Interest was aroused by A.K. Pevnev's report on observations of the course of crustal movement in the region of the Baskunchakskii salt dome, and P.P. Kazanchyan's report on similar studies in Armenia. The papers of G.A. Zhelnin and V.K. Gudelis, read [respectively] by I.P. Lesis and Yu.A. Meshcheryakov, were devoted to the results of studies of recent movements in Estonia and Latvia.

Several papers dealt with "Level Measurements (Oceanographic Observations) as a Method for Study of Recent Crustal Movement". J. Lennon (England) reported on the activities of the Permanent Mean Sea Level Service. P.F. Shikin read M.I. Sinvagina's paper on the analysis of eustatic changes in the level of the World Ocean. This paper showed that the eustatic processes are considerably more complicated than was thought by B. Gutenberg, who estimated the total rise in level of the World Ocean as 1 mm per year. Yu.B. Kaz'min read the paper of A.S. Ionin, P.A. Kaplin, and V.S. Medvedev on methods for determining the structural movement of seacoasts from their geomorphological characteristics. O. Muehlke (East Germany) devoted his report to methods of level measurement. Ch. Weiss (East Germany) presented data showing the sinking of the East German Baltic coast at the rate of about 0.8 mm per year (over 100 years).

R. Tomaschek (West Germany) delivered a paper on "The Application of Tiltmetric and Gravimetric Methods to Study of Recent Crustal Movement", with an analysis of tiltmetric observations in Europe. Yu.D. Bulanzhe devoted his paper to the controversial question of secular changes in the force of gravity. L.A. Latynina read the paper of A.E. Ostrovskii and his colleagues on the results of applying tiltmeters of a new type to study of structural deformations in the Dushanbe region. The symposium's participants also had an opportunity to become acquainted with Professor O. Meisser's hose leveling instrument, the strain seismometer of Doctor L. Hirsemann (East Germany), and the tubular tiltmeter installed at the geophysical station near Tokyo. The application of new instruments opens great vistas in research on the contemporary movement of the earth's crust, and especially in seismic research.

E. Nisimura delivered an interesting paper on "The Connection between Recent Crustal Movements and Earthquakes". The Japanese tiltmetric data which he analyzed show that in some cases disturbance of the secular course of changes in the tilt of the earth's surface is detectable as much as two weeks before the earthquake, which gives hope of ultimate solution of the problem of earthquake forecasting. S. Miyamura (Japan) read A. Sugimura's paper on the special features of crustal movements in Japan. N. Pavoni (Switzerland) expressed a hypothesis of the existence of fields of rotation in the earth's crust. L. Hirsemann read a paper by the renowned structural geologist E. Kraus (West Germany) on the seismostructure of the earth. A. Zatopek presented data on the seismicity of Czechoslovak territory, and A. Tarci-Crornok (Hungary) proposed a new method for determination of the epicenters of earthquakes.

A number of papers were devoted to the geological and geomorphological problems arising in the study of recent crustal movements. The paper of I.P. Gerasimov (AN SSSR), read by A.M. Marinich, gave the general features of the comprehensive method for study of recent movements adopted in the USSR, and clarified the role in it of geological and morphological study. Yu.A. Meshcheryakov's paper included a survey of the data on recent crustal movements and their geological and geomorphological interpretation. V. Khristov and Zh. Gylybov (Bulgaria) reported on the results of research on recent crustal movements in Bulgaria; the mountain ranges in Bulgarian territory are rising (according to preliminary data, by as much as 5 mm per year), while the lowlands between the mountains are sinking. D. Yaranova (Bulgaria) also spoke on the most recent crustal movements in her country. In her paper L.E. Setunskaya suggested original methods for the analysis of longitudinal profiles of rivers with the object of determining recent structural movements. S.K. Gorelov, Z.I. Martynova, and V.A. Mattskova gave in their paper an analysis of the results of the three times repeated leveling of the Ternopol'-Kursk line. The paper of E.A. Fin'ko and E.Ya. Rantsman, read by V.A. Rastvorova, contained a geomorphological interpretation of the results of repeated leveling along the line Arys' — Alma-Ata — Semipalatinsk, which intersects structurally sharply differing sections of the earth's crust. N.V.

Dumitrashko and D.A. Lilienberg gave a paper on recent movements in the Caucasus, while A.P. Rozhdestvenskii and Yu.E. Zhurenko spoke on recent movements in the Urals. M.K. Grave spoke on the characteristics of very recent shifts of the earth's crust in the central part of the Kol'sk peninsula. I.L. Sokolovskii, in his paper, read by L.B. Aristarkhova, pointed out the remarkable inheritance of modern structural movement, deriving from the ancient geological structure, in the territory of the Ukrainian SSR. I. Moiski (Poland) read a paper by B. Ros (Poland) on the geomorphological characteristics of movements of the earth's crust in post-lithorine times on the Baltic seacoast. M. Pécsi (Hungary) considered the manifestation of Holocene crustal movements in Hungarian territory. The lecture of Ch. Fogt (France) was devoted to the quaternary elevation of the Vosges. J. Detomb (France) communicated the data of G. Dubourdier (France) on the recent movements in the border region between Europe and Africa.

The astronomers N. Stoiko and A. Stoiko (France) delivered papers on "Horizontal displacements of continents and the connection between recent crustal movements and abyssal processes". In these papers, which were read by L. Cailler (France), it was proved that there were reciprocal horizontal displacements of Europe and North America amounting to several decimeters per year. Most of the participants in the symposium, however, agreed with V.P. Shcheglov's conclusion that the existing material obtained from astronomical observations does not yet permit an answer to the question of whether there is continental drift at present. T. Kukkamyaki read a paper of F.A. Vening-Meines (Netherlands) on the characteristics of horizontal displacements of the earth's crust within the limits of isolated arcs. The paper of V.A. Magnitskii and E.N. Lyustikh was devoted to the reasons for contemporary movements of the earth's crust. On the basis of his analysis of gravimetric data, the author connects the formation of uplifts and subsidences of the earth's crust with the horizontal displacements of masses beneath the surface and the rarefaction and compression of substances beneath the surface. In his paper, L. Egyed considered recent crustal movements in the light of the theory of the earth's expansion. D. Barta (Hungary) proposed a program of gravimetric observations for the purpose of revealing the overall deformations of the geoid. G. Fanselau (East Germany) considered the possibility of using geomagnetic data to make manifest the movements of the earth's crust.

Papers on applied questions concluded the program of scientific reports. D. Gough (Southern Rhodesia) reported on the geodesic work in the region of the reservoir being filled on the Zambesi River. This work will make it possible to estimate the effect of water masses on the character of deformations of the earth's crust. The papers of Z. Kowalczyk (Poland), K. Neibert (East Germany), and E. Newerowski (Poland) considered the methods and results of study of deformations of the earth's surface connected with open-pit mining in coal basins.

At the concluding session a resolution in which a wide program of international collaboration in study of recent crustal movements figures prominently was moved by the Soviet scientists and was passed (see pp. 78 to 80).

The Leipzig symposium showed that the problem of recent crustal movements presently arouses great interest among scientists of various specialties — geodesists, geophysicists, geologists, and geographers — and that it is acquiring ever more scientific and practical importance. The symposium has undoubtedly made possible further progress, based on international scientific cooperation, in this field.

RESOLUTIONS OF THE FIRST INTERNATIONAL SYMPOSIUM ON RECENT CRUSTAL MOVEMENTS

Thanks

1. The participants in the symposium, scientists of 18 nations belonging to the International Geodesic and Geophysical Union, express their deepest gratitude to the German Academy of Sciences in Berlin and its President, the honored professor V. Chartke, Honorary Chairman of the International Symposium on the Contemporary Movement of the Earth's Crust in Leipzig, to the Committee on Geodesy and Geophysics of the German Democratic Republic, and to its Chairman, Professor H. Philipps, for having made it possible to meet in Leipzig for the discussion of current scientific problems.

2. The participants in the Symposium express their sincerest thanks to the Organizational Committee of the International Symposium on Recent Crustal Movements in the German Academy of Sciences in Berlin and give hearty thanks to the Chairman of the Organizing Committee, Professor O. Meisser, and to all of his colleagues on the Committee for the excellent conditions created for the Symposium, and for their warm friendly welcome.

3. The participants in the Symposium express deep satisfaction at the creation of a permanent Commission on Recent Crustal Movements within the framework of the International Geodesic and Geophysical Union. They express their gratitude to the directorship of the International Association of Geodesy for its support of the Commission's plans for the organization of international scientific cooperation in the field of neotectonics.

The members of this symposium welcome the establishment of contact with the International Geological Union, since the solution of the complicated problem of recent crustal movements requires the united efforts of geodesists, geophysicists, and geologists.

The symposium expresses its gratitude to Special Research Group No. 22 of the International Association of Geodesy and to the Permanent Mean Sea Level Service for the work they have already done and expresses the hope that it will be continued. The Symposium particularly supports the efforts of the Permanent Mean Sea Level Service to broaden the world network of level measuring stations.

International research program

4. The participants of the Symposium note the scientific and practical significance and the foresightedness of research on recent tectonic movement.

The Symposium gives its support to the program of international cooperation in study of recent crustal movements developed by Yu.D. Bulanzhe and Yu.A. Meshcheryakov and comprising:

a) drawing up summary charts of recent crustal movements on the basis of geodesic, oceanographic, geophysical, geological, and geomorphological data, in which cooperation with the International Geographic Union, in the field of geomorphology, is considered highly desirable;

b) international cooperation in organizing observations of variations in crustal movements (creation of special proving grounds for study of local vertical and horizontal crustal movements);

c) close cooperation of the International Geodesic and Geophysical Union with the International Astronomical Union in study of the great horizontal displacements of continents.

With the aim of increasing the activity of scientists of various special interests in studying recent crustal movements the participants of the Symposium recommend the formation of special working groups in national committees in the countries participating in the International Geodesic and Geophysical Union.

5. The International Commission on Recent Crustal Movements (President, Yu.A. Meshcheryakov; Secretary, S. Miyamura) is entrusted with the presentation to the XIII General Assembly of the IGGU in 1963 of a scheme, approved by the present Symposium, for international research on recent crustal movements (taking into account the results of its considerations at this symposium), to obtain final confirmation of the project and to see that recommendations are made for its realization.

6. For overall methodical direction and coordination of international research in accord with the above-mentioned program, it is considered necessary to create within the framework of IAG special research groups for study of the contemporary movement of the earth's crust in various territories. The symposium proposes to begin with the formation of the following working groups:

a) a group to draw up charts of recent crustal movements in Eastern Europe;

b) a group to draw up charts of recent crustal movement in Western Europe;

c) a group to study recent crustal movements in the region of the Pacific Ocean;

d) a group to study the horizontal displacements of continents;

e) a group for proving grounds for study of recent crustal movements and for unification of methods of observation.

It is considered necessary to prepare proposals for the composition of these research groups in the near future.

7. It is desirable that the methods used to study tides in the solid earth and in seismologic research, which reveal completely new possibilities for study of recent crustal movements, find wider application. For this purpose the network of existing stations, as well as the number of instruments at each station, must be expanded.

8. The participants of the symposium observe with satisfaction the experimental compilation of a bibliography on recent crustal movements, including all the research done in Japan, prepared for the present symposium by director S. Miyamura and published by the National IGGU Committee of Japan. All of the countries participating in the IGGU were

asked to perform analogous work. The participants of the Symposium request the Commission on the International Geodesic Bibliography to include in their consideration literature on recent crustal movements.

Exchange of research data

9. Attributing great importance to the regular international exchange of data for study of recent crustal movements, the symposium's participants consider it essential to use world data centers A and B, and to include a division of "Recent Crustal Movements" among the sections whose data are available for exchange in accord with the recommendations of the International Geophysical Committee.

Publication of materials

10. The participants of the Symposium note with thanks the decision of the German Academy of Sciences in Berlin to publish the materials of the present Symposium as a separate volume, prepared for the XIII IGGU General Assembly.

The participants of the Symposium request the editorial committee (Professor O. Meisser, Chairman; Professor Yu.D. Bulanzhe; Dr. Yu.A. Meshcheryakov; Dr. S. Miyamura; Professor Ch. Peschel, East Germany; and Professor K. Reicheneder) to take upon themselves the preparation of this volume.

Next Symposium

11. To ask the International Association of Geodesy to hold the next Symposium on Recent Crustal Movements in 1965, and to take the necessary measures for its preparation within the framework of the IGGU.

S. L. Solovev

WITH SWEDISH GEOPHYSICISTS

In the summer of 1962 the present author was sent to Sweden by the Academy of Sciences of the USSR to visit the seismological institute of the University of Uppsala. The main aim of the mission, which lasted four weeks, was to learn how seismological studies are organized in Sweden and also to study the spectra or seismic waves through the seismograms of Swedish stations /1, 2/.

The author also had the opportunity to visit several institutions not directly connected with seismology, including the observatory of the Academy of Sciences of Kirun, and the "AB Elektrisk Malmletning" in Stockholm, a company producing geophysical equipment.

The Seismological Institute of the University of Uppsala. The town of Uppsala, with a population of about 100,000, is situated 70 km north of Stockholm. The university of Uppsala, which was founded in 1477, and is at present the largest in the country and in Northern Europe, has produced such outstanding scholars as C. Linné, A. Celsius, K. V. Scheele, and T. Svedberg. The Faculty of Natural Sciences includes many specialized research institutes, including the Seismological Institute, which is located in the two-storeyed building of the Limnological Institute on the outskirts of the university park. The head of the institute is the renowned seismologist M. Bot. Five out of the six seismological stations in the country belong to the institute, and are located at Uppsala (where the underground station is near the institute building), Skalstugan, Umeå, Göteborg, and Karlskruna. The sixth, at Kirun, belongs to the Academy of Sciences. The stations are equipped with modern short- and long-period seismographs of Swedish and American manufacture. The Swedish net of seismological stations is at present equipped with the most sensitive apparatus in the world.

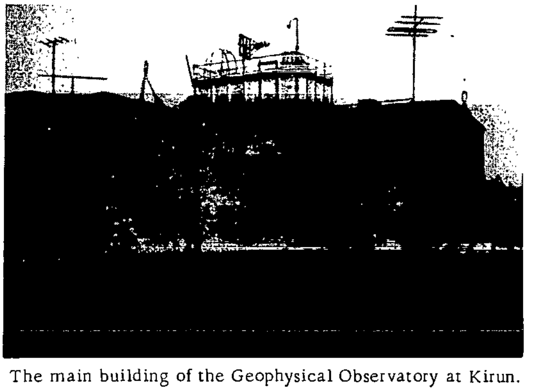
Scientific research is conducted on a variety of subjects, but manpower is limited to Bot and the institute's temporary workers, who are almost exclusively foreigners. At present the institute is primarily occupied with the study of the structure of the earth's crust in Scandinavia, the Arctic, and the North Atlantic, by a combination of methods (abyssal seismic sounding, utilization of exchange phases, and study of the dispersion of surface waves /1/). *

The Geophysical Observatory of the Academy of Sciences at Kirun. The small town of Kirun is situated at the latitude of 67.8°, i. e., above the northern Polar Circle. Its latitude was one of the principal reasons for the

* For further details see: S. L. Solov'ev. Otchet o rabote v Shvetsii 19 iyunya — 17 iyulya 1962 g (A Report on Work in Sweden 19 June to 17 July, 1962). Stores of Sakh KNII and of Instituta Fiziki Zemli of the AN SSSR.

choice of Kirun as the location of the Main National Observatory, which is primarily concerned with the physics of the atmosphere.

The observatory, which is a nicely finished L-shaped building dating from the beginning of the 1950's, is in a forest about 5 km east of the town center (see illustration). The two-storied longer wing of the "L" contains the living quarters and domestic offices (kitchen, dining-room, bathroom, laundry, etc.), while the shorter three-storied wing contains the laboratories, the director's office, the library, and other working quarters. On the flat roof are a spacious glazed box adapted to the installation of various instruments, and pedestals fastened to the rocky ground by special pipes which are not connected to the building.



The main building of the Geophysical Observatory at Kirun.

There are a good many special instrument huts distributed over an area of 22.2 km^2, at distances ranging from a few dozen meters to ten or twenty kilometers from the main building. The employees live in Finnish type houses near the observatory, or in the town.

The observatory was opened in 1956 /1/. The following research was done at the observatory in the years 1961-62:

1. Geomagnetic observations:

a) recording the components of the earth's magnetic field using Lya-Kara instruments with normal recording speed (15 mm/hr) and sensitivity of the order of 10 g/mm, and magnetometers with higher recording speed (190 mm/sec), and sensitivity of the order of 5 g/mm;

b) recording storms by instruments of the same type with a sensitivity of 20 to 30 γ/mm and a recording speed of 10 mm/hour;

c) ink recording of the X component on punched cards using a Rask magnetometer and Vestin-Chernyavski automatic recorder (sensitivity 5 γ/mm, recording speed 40 mm/hour);

d) recording the sonic range (10 to 10,000 cps) of the vertical component of the electromagnetic field in the zone of the aurora polaris, using an Aaron spectrometer (sensitivity of 1.5 γ/mm, speed of paper 30 cm/hour).

e) the study of field variations within the range of 1 to 10 cps.

2. Observations of the polar aurorae:

a) photography of the sky by a Shtofregen camera at 1-minute intervals, with a 9-second exposure;

b) recording the vertical intensity of the 5577Å line by an instrument with a sensitivity of 1 mm deflection per 100 relays and a recording speed of 80 mm/hr

c) recording the aurorae by a six-color spectrophotometer.

3. Radio observations of the polar aurorae.

a) reception of an 88.5 Mc frequency modulated wave propagated through the region of the polar aurorae from a transmitter 45 km south of Kirun;

b) radio tracking of the aurorae at a frequency of 83 Mc;

c) the study of irregularities and fine structure of the ionosphere in the zone of the polar aurorae, particularly at the beginning of the phenomenon and of geomagnetic storms, using a radio astronomy interferometer with variable frequency within the range 35 to 65 Mc.

4. Ionospheric observations:

a) measuring the height of the ionosphere by panoramic radar with variable frequency (0.5 to 15 Mc);

b) as above, using radar continuously operating at set frequencies of 3.0 and 6.7 Mc;

c) radiometer measurements of the absorption of 27.6 Mc waves in the ionosphere.

5. Study of radio wave propagation:

a) transpolar reception of 12 and 18 Mc radio emission from College (Alaska) and film recording of the signals;

b) reception of extra-long-period radiation from Rugby (England), at 16,000 Kc and Balboa (Canal Zone), at 18,000 Kc, with a recording speed of 65 mm/hour and signal intensity of 20 microvolts/m at Rugby;

c) reception of 136.5 Mc radiation from the 1961-02 (Injun) satellite and others.

6. Study of cosmic rays:

a) using three cubic meson telescopes with a counting speed of about 18,000 coincidences per hour;

b) using a specially aimed meson telescope with 2 × 4 channels (i. e., with four double channels), and a counting speed of ~ 16,000 coincidences per hour;

c) using 16 Geiger-Muller counters distributed on an area of 150 × 120 m and recording about 18 showers per hour.

7. Standard seismic observations.

8. Standard meteorological observations.

Dr. Hulquist, the head of the observatory, is doing basic research on radio wave propagation. Several other scientists, mostly foreigners, whose number varies, work at the observatory. In the summer of 1962 the following scientists worked at the observatory: A. Egeland (Norway) was studying the polar aurorae by means of radio observations; L. Liska (Poland) studied the fine structure of the polar aurorae using a radio-interferometer; Gustavson (Sweden) directed observations of the polar aurorae; Ortner (Austria) and T. Elkins (Australia) worked in their special field of long radio wave propagation; V. Ridler (Austria) was interested in hydrodynamic waves, and Z. Grabovskii (Poland) studied X-rays. Most of the routine work is done by six laboratory assistants. Five engineers and three technicians take care of the construction, installation, and repair of instruments. A workshop, excellently equipped with Swedish machine-tools and instruments, occupies a spacious hall and three adjoining rooms. All the work of the workshop, smithy, and drafting room is entrusted to a single man. There is also a small joiner's shop in the observatory. The janitor in charge of the general maintenance of the premises is housed with his family in the observatory building.

"Ab Elektrisk Malmletning" (ABEM), a company manufacturing geophysical equipment, was established in 1923. Its original aim was to produce and develop equipment for geoelectric and magnetic prospecting, since these are the best methods for seeking ores, which are Sweden's principal mineral resource. The company gradually broadened its activities, creating a seismic division in 1934, and a gravimetric division in 1937. After the war ABEM turned to the production of instruments for radiometric prospecting and for industrial research (automatic recorders, vibrographs, etc.). At present, in addition to the sections producing instruments, the company has research laboratories for the development of new kinds of instruments and a geophysical subsidiary which does prospecting under contract both in Sweden and abroad.

ABEM is able to send out as many as twenty parties of field workers simultaneously, and has done prospecting in more than 50 countries.

The following instruments are at present the principal products of the company:

1. For aeroprospecting:

a) instruments for electromagnetic prospecting by the rotating field method, using two airplanes;

b) the same as above, using only one airplane;

c) equipment for aerial magnetic surveys;

d) equipment for radiometric surveys.

2. Instruments for seismic surveying and related engineering:

a) instruments designed to use the method of reflected and refracted waves, mainly to map the base of the crystalline foundation (for selection of locations for the construction of dams, ports, factories, tunnels, determination of the thickness of glaciers, etc.). The accuracy of determination is ±10 % for foundations 10 m or more in depth;

b) A 12-channeled portable station designed to work on the method of refracted waves, with low frequency (4 and 12 cps) seismic detectors of American manufacture. The station, which has a total weight of 70 kg, is designed to be carried and serviced by three men.

3. Instruments for surface exploration:

a) MZ-4 magnetometer for ore or oil prospecting;

b) OKU penetration meter for borehole determination of the quality of magnetic ore;

c) a portable electromagnetic "pistol" invented by ABEM to discover conducting layers down to a depth of 50 m;

d) Turam equipment for electromagnetic prospecting down to a depth of 200 m;

e) instruments for semi-absolute electromagnetic field measurement;

f) terrameter for determination of the geoelectrical resistance of rocks;

g) equipment (SP792) to measure the natural potential or ore bodies;

h) Norgard gravimeter, with sensitivity of 0.05 milligram liter, and range of about 2000 milligram liter, designed mainly to replace pendulum instruments in geodesic research.

4. Engineering equipment:

1) oscillographs of various types with visible recording or recording on photographic paper:

a) Ultragraph — a 14-channel oscillograph with visible recording, for the study of processes of brief duration. Paper sensitive to ultraviolet rays and self-developing in daylight is used for this purpose. The recording speed varies smoothly from 0.1 to 80 cm/sec (in other models the total range covered is from 1 mm/min to 3 m/sec);

b) Ultralett — an improved ultragraph with 24 channels, a wider velocity range and many auxiliary accessories;

c) an oscillograph to record processes of brief duration (recording speed 60 to 100 m/sec).

2) Automatic recorders, for the most part using heat-sensitive paper:

a) OS-1195 automatic recorder with five working channels and two for notation of time (or other coordinates). The natural frequency of the galvanometers is 2.5 cps, and their sensitivity, 25 mm per 1 Å. The maximum possible recording amplitude is 25 mm;

b) a 60-channel automatic recorder recording on electrostatic paper. The paper starts moving after a signal reaches one of the 60 channels, and stops after moving 60 mm or some other predetermined distance. It is used to check on work in shops, railway junctions, etc.

3) Galvanometers for oscillographs.

4) Semiconducting transformers with an output voltage of up to 1000 v.

5) Multichannelled amplifiers for connecting a number of special instruments (for instance mass spectrographs) to oscillographs and recorders produced by ABEM.

6) Special power supplies (portable slides).

In addition to the institutions described above, there are in Sweden several other organizations engaged in geophysical research:

a) The Institute of Electronics of the Higher Technical School of Stockholm is doing research on cosmic rays, the ionosphere, the polar auroras, and explanation of the nature of geomagnetism.

b) The Geotechnic Institute develops designs for tiltmeters and conducts observations of the development of landslides, etc.

c) The Nitroglycerine Society studies the seismic effects of explosions which are for the most part made for building purposes.

d) The Swedish Geological Service is making a gravimetric and radiometric survey of the country.

e) The Geographic Institute is determining the thickness of glaciers by seismic methods.

Geophysical research in Sweden is to some extent coordinated by the National Committee on Geodesy and Geophysics, most of whose several dozen members are meteorologists and geophysicists concerned with the study of the atmosphere.

In conclusion I would like to note the cordial and well-organized receptions I met with everywhere. During the discussions attention was called to the unavailability of information about the work of Soviet geophysicists in Sweden, and hope for the development of scientific ties and direct contact between researchers from the two countries was expressed.

Bibliography

1. Solov'ev, S. L. Seismologiya v Shvetsii (Seismology in Sweden). — Izvestiya AN SSSR, geophysical series (in press).
2. Solov'ev, S. L. O seismichnosti Shvetsii (Seismicity of Sweden). — Izvestiya AN SSSR, geophysical series (in press).
3. Swedish Geophysical Observatory. Science 126, N 3276, p. 691, 11 October, 1957.

M. G. Kroshkin and V. G. Samarin

FIVE YEARS OF SOVIET SPACE RESEARCH

This survey constitutes a brief reference work for the fundamental stages of Soviet space research over the five years of the "space age" (1957 to 1962). Data on all of the space vehicles launched between 1957 and 1962 are presented (Tables 1 to 5).

The Soviet Union launched the first artificial earth satellite on 4 October, 1957, the second, a month later, and the third, in May, 1958.

All three were launched for geophysical purposes, as part of the program of the 1957-1958 International Geophysical Year (IGY). The satellite launchings, together with comprehensive rocket research, gave special value to the IGY research, since they made it possible for the first time to obtain direct experimental data on the upper atmosphere, the shortwave and particle radiation of the sun, primary cosmic rays, meteoric matter, etc.

The first satellite provided data on the density of the upper atmosphere and the properties of the ionosphere, as well as on the thermal regime of artificial satellites moving in a space orbit. This was of immediate geophysical value and was a necessary stage in the transition to further research. The next launching envisaged a wider research program, and also included a biological experiment. The third satellite, whose weight (1327 kg) was enormous even in the light of more recent achievements, was essentially a unique space laboratory, which permitted Soviet scientists to conduct research on the whole comprehensive IGY program at once, and more exactly, on the part of it devoted to satellites.

The next stage in space research was the launching, in 1959, of three space rockets. The first of these studied the space neighboring the earth and the moon and become the first artificial planet of the solar system. The second reached the moon and investigated space along the route between earth and moon. The third put the first automatic interplanetary station into a complicated orbit. This station, besides making various physical investigations, photographed the hidden side of the moon and automatically relayed the pictures to the earth — an achievement not repeated to the present day, more than three years later.

In 1960 preparations for manned space flight made great progress. Satellite-ships were launched one after another, engineering systems and various flight stages were developed, and the effect of the specific conditions of space flight upon living organisms was tested by direct experiments with animals.

It should be pointed out that at the same time scientific data of exceptionally great geophysical interest were obtained, particularly with reference to study of the structure of the lower edge of radiation zones. It turned out that they not only are asymmetrical with the shape of the earth (i.e., the "globe") through noncoincidence of the magnetic dipole with the center of the earth, but that they change their configuration in regions where the earth's magnetic field is anomalous. In fact, in the region of the planetary Brazilian anomaly, located in the South Atlantic near the shores of Brazil, the edges of the radiation belt approach to within 300 km of the surface of the earth.

In 1961 the first launching of an automatic station to Venus took place, two experimental satellite-spaceships were launched, and most important, the Soviet astronauts Yuri Alekseevich Gagarin and German Stepanovich Titov made their first space flights.

The great accomplishments of Soviet science and engineering in 1962 included the several-day group flight around the earth of Andriyan Grigor'evich Nikolaev and Pavel Romanovich Popovich in the satellite-spaceships "Vostok-3" and "Vostok-4". On 1 November, 1962 for the first time an automatic interplanetary station "Mars-1" was launched to Mars as part of the Soviet program of research on outer space and on the planets of the solar system.

On 16 March 1962 TASS reported that the Soviet Union had begun to launch the "Cosmos" series of artificial earth satellites as part of a wide program of scientific research on the upper layers of the atmosphere and on outer space. This program envisages the following research:

1) study of charged particle concentration in the ionosphere for research on radio wave propagation;

2) study of corpuscular streams and low-energy particles;

3) study of the energy composition of the earth's radiation belt for evaluation of radiation danger in prolonged space flight;

4) study of the primary composition of cosmic rays and variations in their intensity;

5) study of the earth's magnetic field;

6) study of the shortwave radiation of the sun and other celestial bodies;

7) study of the upper layers of the atmosphere;

8) study of the effect of meteoric matter on the structural elements of cosmic objects;

9) study of the distribution and formation of cloud systems in the earth's atmosphere.

Beyond this, many aspects of the design of space vehicles must be elaborated. In 1962 twelve "Cosmos" satellites were launched (see Table 5).

Wide prospects for space research, both geophysical and astronomical, stand before scientists. The forthcoming (1964-1965) research for the International Years of the Quiet Sun (IQSY) will have great significance. It is to be expected that research assisted by rockets and satellites will play an even greater part than during the IGY.

In this brief survey it is difficult to enumerate all the results obtained by means of artificial earth satellites during the IGY. They have been published in various scientific publications. Below is a list of the basic literature containing the official material on the launching of Soviet space vehicles, flights of Soviet astronauts, and fundamental research results obtained in the Soviet Union by the use of rockets and satellites. Further information about literature on rocket and satellite research can be found in papers /33/ and /34/.

The fundamental information about the space craft launched by the Soviet Union between 1957 and 1962 is given in Tables 1 to 5.

APPENDIX

SOVIET ARTIFICIAL EARTH SATELLITES, SPACE ROCKETS, AUTOMATIC INTERPLANETARY STATIONS AND SATELLITE-SPACESHIPS (1957-1962)

TABLE 1. Artificial Earth Satellites (AES)

Name and accepted international designation	Date of launching	Weight, kg	Initial orbital data				Duration of existence (flight), days	Number of revolutions about the earth	Distance traveled, millions of km
			Perigee, km	Apogee, km	Period of revolution about the earth, min	Angle of inclination of plane of orbit to plane of earth's equator			
First AES[1] 1957-α	4 October, 1957	83.6	228	947	96.17	65°.1	92	About 1400 1400	About 60
Second AES[2] 1957-β	3 November, 1957	508.3 (weight of instrumentation, experimental animal, and power supply)	225	1671	103.75	65.3	163	About 2370	Over 100
Third AES[3] 1958-δ	15 May, 1958	1327 (of which 968 kg constitute weight of scientific and radio measuring instrumentation and power supply)	226	1881	105.95	65,2	691	10,037	Over 448
Heavy AES[4] 1961-β	4 February, 1961	6483 (not counting weight of last stage of rocket-carrier)	223.5	327.6	89.8	64,57	Till 26 February, 1961	—	—
Heavy AES[5] 1961-γ	12 February, 1961	—	222	280	98.6	65°	Till 25 February, 1961	—	—
Heavy AES[6] 1962-β_{v}	1 November, 1962	—	—	—	—	—	—	—	—

[1] The satellite was launched as part of the IGY program envisaging research on the upper layers of the atmosphere and the space neighboring the earth. The experiments on the satellite included: 1) measurement of the temperature and pressure inside the spherical body of the satellite (diameter 58 cm); 2) temperature regulation inside the satellite by altering the forced circulation of gaseous nitrogen (in accord with the temperature); 3) determination of the density of the upper layers of the atmosphere (by braking the motion of the satellite); 4) ionospheric research (by observing the propagation of radio waves emanating from the satellite).

The frequencies of the two radio transmitters were 20.005 and 40.002 Mc (corresponding, respectively, to wavelengths of 15 and 7.5 m) with signal duration, in the form of telegraphic pulses, of about 0.3 sec and pauses of the same duration. A signal of one frequency was transmitted during the pause of a signal of the other frequency.

This was the world's first AES, the first artificial body fashioned by human hands, to be sent into space. On 4 January, 1958 it entered the dense layers of the atmosphere and terminated its existence.

[2] The satellite launching was part of the IGY program. The projected scientific research on the satellite was planned for seven days and was carried out in full. The experiments included: 1) research on solar radiation in the shortwave ultraviolet and X-ray regions; 2) study of cosmic rays; 3) recording of changes in temperature, pressure, and other parameters in the spherical container and cabin with the experimental animals; 4) medical and biological study of the vital activity of the experimental dog Laika under space flight conditions; 5) determination of the density of the upper atmosphere (by braking the motion of the satellite); 6) ionospheric research (by observing the propagation of radio waves emanating from the satellite).

The frequencies of the two radio transmitters were 20.005 and 40.002 Mc (corresponding, respectively, to wavelenghts of 15 and 7.5 m). The first operated under conditions of continuous emission, while the second emitted signals like telegraphic pulses, of duration about 0.3 sec with pauses of the same duration.

On 14 April, 1958 the satellite entered the dense layers of the atmosphere and was destroyed. Available data indicate that separate parts of the satellite were scattered along a route passing over the Lesser Antilles, Brazil, and the Atlantic Ocean, in a southeasterly direction.

[3] An IGY launching. The following research was performed on the satellite: 1) pressure and composition of the upper layers of the atmosphere; 2) positive ion concentration; 3) magnitude of the electric charge of the satellite and intensity of the earth's electrostatic field; 4) intensity of the earth's magnetic field; 5) intensity of the corpuscular radiation of the sun; 6) composition and variations of primary cosmic radiation, and distribution of photons and heavy nuclei in cosmic rays; 7) micrometeorites; 8) temperature inside and on the surface of the satellite.

The radio transmitter ("Mayak") had a frequency of 20.005 Mc with telegraphic pulses of duration 50 to 300 msec with high emissive power.

On 6 April, 1960 the satellite entered the dense layers of the atmosphere and terminated its existence. Calculations indicate, in accord with the data of the last observations, that on its revolution the satellite had a period of about 87 min.

[4] Launched in accord with a scheme to create and develop heavy spaceships. A radiotelemetric system to check design element parameters and the instrumentation for trajectory measurements was installed on the satellite.

The scientific and engineering objectives proposed at the launching of the satellite were all attained.

[5] An improved multistage rocket was used to put the heavy satellite into an intermediate orbit around the earth, so that a guided space rocket with an automatic interplanetary station could be launched from it in the direction of Venus. The guided rocket which put the automatic interplanetary station into a trajectory to Venus started with the satellite.

[6] The last stage of an improved rocket-carrier was used to put the heavy satellite into an intermediate orbit around the earth so that a space rocket bearing the automatic interplanetary station "Mars-1" could be launched from it in the direction of Mars. The space rocket which put "Mars-1" into its trajectory to Mars started with the satellite.

TABLE 2. Space rockets and automatic interplanetary stations (AIS)

Name and accepted international designation	Date of launching	Weight of last stage of rocket-carrier (not counting fuel), kg	Total weight of scientific measuring instrumentation with power supply and container, kg	Weight of AIS, kg	Orbital data				Duration of existence (flight)
					Perihelion, km	Aphelion, km	Angle of inclination of plane of orbit to plane of ecliptic	Period of revolution about the sun, days	
First space rocket[1] 1959-μ	2 January, 1959	1472	361.3	—	About 146.4 million	About 197.2 million	About 1°	About 450	Became a satellite of the Sun
					(Eccentricity of orbit -0.148)				
Second space rocket[2] 1959-ξ	12 September, 1959	1511	390.2	—	—	—	—	—	Reached the surface of the moon in the region of the Mare Serenitatis, 800 km from the center of the visible disk of the moon
Third space rocket and AIS to moon[3] 1959-θ	4 October, 1959	1553	156.5	278.5	About 40 thousand (Perigee)	About 480 thousand (Apogee)	—	About 15 (Period of revolution about the earth	The AIS, after overshooting the moon and becoming an AES, completed 11 or 12 revolutions about the earth and in April, 1960 burned up in the dense layers of the terrestrial atmosphere
Space rocket and AIS to Venus[4] 1961-γ	12 February, 1961	—	—	643.5	106 million	151 million	0.5	—	Became a satellite of the sun
Space rocket and AIS "Mars-1" to Mars[5] 1962-β_ν	1 November, 1962-	—	—	893.5	—	—	—	—	

[1]The measuring apparatus installed on the rocket was intended to perform the following scientific research: 1) detection of the moon's magnetic field; 2) study of the intensity and variations in the intensity of cosmic rays outside the earth's magnetic field; 3) recording of photons in cosmic radiation; 4) detection of the moon's radioactivity; 5) study of the distribution of heavy nuclei in cosmic radiation; 6) study of the gaseous component of interplanetary matter; 7) study of corpuscular solar radiation; 8) study of meteoritic particles. Beyond these, special instrumentation for creation of a sodium cloud — an artificial comet — was installed on the rocket.

To observe the flight of the last stage of the space rocket the following radio transmitters were installed on it: 1) transmitting at two frequencies, 19.997 and 19.995Mc, telegraphic pulses 0.8 and 1.6sec in duration; 2) transmitting at a frequency of 19.993Mc, telegraphic pulses of variable duration, of the order of 0.5 to 0.9sec (this was used to transmit the data of the scientific observations); 3) transmitting at a frequency of 83.6Mc and used to measure the parameters of the rocket's motion and to transmit scientific information to the earth.

On 4 January, 1959 the rocket passed closest to the moon, when, according to precise data, its distance from the moon was 5000 to 6000km. About 7 or 8 January the rocket went into an independent orbit about the sun, became its satellite and the first artificial planet of the solar system.

[2]The measuring instruments installed on the rocket were designated to perform the following research in space as the rocket flew to the moon: 1) study of the magnetic fields of earth and moon; 2) radiation belts about the earth; 3) intensity and variations in the intensity of cosmic radiation; 4) heavy nuclei in cosmic radiation; 5) the gaseous component of interplanetary matter; 6) meteoric particles. Beyond this, the rocket had special apparatus for creation of an artificial comet — a sodium cloud.

The following radio transmitters were installed on the rocket to transmit all scientific information to the earth, measure the parameters of motion and check on the rocket's flight: 1) operating at two frequencies, 20.003 and 19.997Mc, emitting signals in the form of telegraphic pulses from 0.8 to 1.5sec in duration (during pauses in transmission at the first frequency pulses at the second frequency were transmitted); 2) operating at frequencies of 19.993 and 39.986Mc, with pulses of variable duration from 0.2 to 0.8sec with pulse repetition frequency of 1 ± 0.15Mc; 3) operating at a frequency of 183.6Mc.

The second space rocket first completed a space flight from the earth to another celestial body — the moon. In honor of this event a Soviet penant was set up on the surface of the moon with the superscription: "Union of Soviet Socialist Republics. September 1959"

[3]The projected program of scientific research included the pictures obtained of the invisible side of the moon and their subsequent transmission to the earth by means of instrumentation installed on the AIS, as well as research in interplanetary space.

Scientific information and the results of measurement of the parameters of motion of the AIS were transmitted by means of two radio transmitters operating on frequencies of 39.986 and 183.6Mc. The signals of the first transmitter were pulses of variable duration from 0.2 to 0.8sec with a repetition frequency of 1 ± 0.15Mc.

During this flight of the AIS put into a round-the-moon trajectory by the third space rocket, the side of the moon never seen from the earth was glimpsed for the first time. The photography of the moon from a distance of 60,000 to 70,000km lasted about 40 minutes, during which a considerable number of photographs of the moon's invisible side (on two different scales) were obtained. The films were automatically developed and printed on board the AIS. The moon photographs were transmitted to the earth in the form of signals by a special electronic system, which simultaneously transmitted the data of scientific measurements, made orbit calculations, and transmitted operational commands from earth to the AIS. A television set was used for transmission to earth of a half-tone image of the moon with high resolution. Moon pictures were transmitted from the AIS up to a distance of 470,000km. This provided the first empirical evidence that high-definition half-tone images are capable of extra-long-range transmission in space with no real scientific distortions occurring in the process of radio wave propagation.

[4]Fundamental objectives of the launching: testing methods of putting a cosmic object into an interplanetary trajectory, testing extra-long-range radio communications and control of a space station; precise determination of the scale of the solar system and performance of a number of physical measurements with the object of studying cosmic rays, magnetic fields, interplanetary matter, and the recording of collisions with micrometeorites. The frequency of the radio transmitter on the AIS was 922.8Mc

The AIS directed to Venus was launched by a guided space rocket which started from a heavy AES put into an intermediate orbit. On 19-20 May, 1961, the AIS passed at a distance of 100,000km from the surface of Venus, having traveled a total of about 270,000km. This was the first instance of a new launching system involving the start of a rocket from an AES previously put into an intermediate orbit. It also marked out for the first time a route to a planet of the solar system.

[5]The rocket directed to Mars ("Mars-1") was launched as part of a program of research on outer space and the planets of the solar system. The fundamental objectives of the AIS "Mars-1" launching were: 1) prolonged study of outer space during the flight to Mars; 2) establishment of interplanetary radio communications in space, 3) photography of Mars and subsequent transmission to earth of the pictures of the surface of Mars by radio channels.

The telemetric, measuring, and scientific equipment was automatically operated in accord with the flight program and by radio commands from earth. A special combination of measuring apparatus and a center of long-range radio communication in space served to follow the flight of the AIS, determine the parameters of its trajectory, and receive its scientific information on the earth. The AIS carried radio transmitters with frequencies of 922.76 and 183.6Mc. Three radio systems, operating respectively on waves in the meter (1.6m), decimeter (32cm), and centimeter (5 and 8cm) ranges were installed on the station.

The AIS "Mars-1" was launched by a rocket which started from a heavy AES previously put into an intermediate orbit. Preliminary results obtained from the measurements showed that the AIS followed a trajectory close to that calculated. Precise determination of the trajectory elements showed that disregarding corrections, the trajectory of the AIS passed at a distance of 261,000km from Mars. The design on the AIS provided for correction of its motion in the course of flight by radio commands from earth by means of a precise system of astronavigation and a special power booster to ensure that the AIS would pass at an altitude of 1000 to 11,000km above the surface of Mars.

On 2 November, 1962 Soviet observatories photographed the AIS "Mars-1" and the space rocket against the background of the night sky. On the resulting photographs they appeared as stars of the 14th and 13th magnitude, respectively.

Radio communications with the AIS as far as Mars were maintained at distances of more than 100 million km.

TABLE 3. Satellite-spaceships.

Name and accepted international designation	Date of launching	Weight (without last stage of rocket-carrier), kg	Initial orbital data				Date of landing	Duration of flight	Number of revolutions about the earth
			Perigee, km	Apogee, km	Angle of inclination of the orbital plane to plane of terrestrial equator	Period of revolution about the earth, min			
First satellite-spaceship[1] 1960-ε	15 May 1960	4540 (weight of equipment and power supply on board)	312	369	65°	91.2	Not stipulated	63 days	1017
Second satellite-spaceship[2] 1960-λ	19 August 1960	4600	306	339	65°57'	90.7	Landed upon command from earth, 20 August, 1960	1 day	17
Third satellite-spaceship[3] 1960-ρ	1 December 1960	4563	187.3	265	65°	88.6	Entered the dense layers of the atmosphere and terminated its existence, 2 December, 1960	1 day	17
Fourth satellite-spaceship[4] 1961-θ	9 March 1961	4700	183.5	248.8	64°56'	88.6	Landed upon command from earth, 9 March 1961	1 hr 46 min	1
Fifth satellite-spaceship[5] 1961	25 March 1961	4695	178.1	247	64°54'	88.42	Landed upon command from earth, 25 March, 1961	1 hr 45 min	1

[1] The launching was intended to contribute to the development and testing of satellite-spaceship systems which would assure safe, controlled flight with return to the earth, as well as the conditions necessary for manned space flight. Furthermore, provision was made for separation from the satellite-ship (without return to the earth) of a hermetic cabin weighing about 2.5 tons. This launching of the first satellite-spaceship laid the foundation of the complicated task of building dependable spaceships for safe manned space flight, and demonstrated the correctness of the fundamental assumptions in spaceship construction. The satellite-ship carried a hermetic cabin with a load equivalent to that of a man, and with everything necessary for subsequent manned space flights.

Due to the manfunctioning of the orientation system, the ship, instead of descending, rose and entered a new elliptical orbit with perigee 307 km and apogee 690 kg, period of revolution 94.25 min, and angle of inclination to the plane of the equator 69°.

[2] Fundamental objective of the launching — further development of systems to assure vital human activity, as well as safe flight and return to the earth. Provision was made for performance of a number of medical and biological experiments during flight, as well as a program of scientific space research (on light and heavy nuclei in primary cosmic radiation, X-ray and ultraviolet solar radiation, and recording of the dose level of cosmic radiation in the compartment for animals). The ship's cabin contained experimental animals (two dogs — Strelka and Belka, 40 mice, 2 rats, insects, plants, cereal grains, and several microbes).

Radio transmitters ("Signal") and radio telemetric equipment for transmission to earth of information about the condition of the experimental animals and the operation of all systems on board were installed on the satellite-ship. A radio television system for observation of the behavior of the animals on board the satellite-ship was included.

This was the first time that a satellite-spaceship with living creatures returned to the earth.

[3] Fundamental objective of the launching — further development of satellite-ship design and fundamental on-board systems necessary for manned flight in outer space; performance of medical and biological research in space flight conditions (the experimental animals included the dogs Pchelka and Mushka, and other animals, as well as insects and plants); a number of scientific studies on the physics of outer space. The behavior of the animals was observed by means of radio and television equipment and telemetric systems.

The ship started along an uncharted trajectory, as a result of which its existence was terminated when it entered the dense layers of the atmosphere.

[4] Fundamental objective of the launching — further development of satellite-ship design and of the basic systems required for manned space flight; performance of medical and biological research (the experimental animals included the dog Chernushka, mice, guinea-pigs, frogs, insects, plants, grains, and other biological objects). Telemetric and television systems, a radio-tracking system for trajectory measurements, and radio communications apparatus were installed on the satellite-ship. The cabin contained a mannikin representing an astronaut.

[5] Fundamental objective of the launching — further development of satellite-ship design and of basic systems necessary for manned space flight; performance of medical and biological research (the experimental animals included the dog Zvezdochka, laboratory mice, guinea-pigs, frogs, microbes and viruses, ray fungi, dry seeds of various plants, shoots of onion, as well as a solution of desoxyribonucleonic acid and various ferments). The satellite-ship contained a mannikin astronaut.

TABLE 4. "Vostok" satellite-spaceships

Name and accepted international designation of satellite-ship. Pilot.	Date of launching and (Moscow) time of start	Weight of ship (disregarding weight of last stage of rocket-carrier), kg	Initial orbital data				Date and (Moscow) time of landing	Place of landing: coordinates	Duration of flight	Number of complete revolutions about the earth, with astronaut	Length of flight, km
			perigee, km	apogee, km	angle of inclination of orbital plane to plane of terrestrial equator	period of revolution about the earth, min					
"Vostok-1"[1] 1961-μ Major Yurii Alekseevich Gagarin	12 April, 1961 9 hr 7 min	4725	181	327	64°57'	89.1	12 April, 1961 10 hr 55 min	In the region of Smelovka village, Ternovskii region, Saratov Province, RSFSR, 50°16' n. lat., 45°59' e. long.	1 hr 48 min	1	More than 40,000
"Vostok-2"[2] 1961-τ Major German Stepanovich Titov	6 August, 1961 9 hr 00 min	4731	183	244	64°56'	88.46	7 August, 1961 10 hr 18 min	In the region of Krasnyi Kut village, Saratov Province, RSFSR, 50°51' n. lat., 47°1.5' e. long.	25 hr 18 min	17	703,150
"Vostok-3"[3] 1962-αμ Major Andrian Grigor'evich Nikolaev	11 August, 1962 11 hr 30 min	4722±5	180.7	234.6	64°58'50"	88.33	15 August, 1962 9 hr 52 min	Southern Karagandy, Kazakh. SSR Pilot: 48°02' n. lat 75°45' e. long. "Vostok-3": 48°00' n. lat. 75°45' e. long.	94 hr 22 min	64	About 2.64 million
"Vostok-4"[3] 1962-αγ Lieutenant-Colonel Pavel Romanovich Popovich	12 August, 1962 11 hr 2 min	4728±5	179.8	236.7	64°57'10"	88.39	15 August, 1962 9 hr 59 min	Southern Karagandy, Kazakh. SSR Pilot: 48°10' n. lat. 71°51' e. long. "Vostok-4": 48°9' n. lat. 71°51' e. long.	70 hr 57 min		

[1] Object of flight — to test influence of spaceflight conditions on a human organism and accomplish successful landing of ship with astronaut in a designated place on the earth. USSR citizen Yu. A. Gagarin made the world's first space flight and successful earth landing in a given region. His flight opened man's path into space. The satellite-ship "Vostok" was put into orbit around the earth by a multistage rocket-carrier with 6 liquid rocket engines having a total maximum power of 20 million h. p. (all stages).

[2] Objects of the flight: 1) to study the effect on a human organism of prolonged (one day) space flight in an orbit about the earth with subsequent landing on the surface of the earth; 2) to study human efficiency in protracted condition of weightlessness. G. S. Titov's flight was the world's first day-long orbital human flight about the earth. The satellite-ship "Vostok-2" was put into orbit around the earth by a multistage rocket-carrier with six liquid rocket engines having a total maximum thrust of 600,000 kg (all stages).

[3] Objects of putting "Vostok-3" and "Vostok-4" into low orbits: 1) to obtain experimental data on the possibility of establishing direct contact between two ships; 2) to coordinate the action of the astronauts; 3) to test the effect of identical space flight conditions on different human organisms. Furthermore, research and experiments necessary to solve a number of new medical, biological, and engineering problems were planned for this flight.

This was the world's first simultaneous multistage group space flight of two satellite-ships. The range of the flight of "Vostok-3" and "Vostok-4" of 12-15 August, 1962 was 1,975,200 km, and its duration 70 hr 23 min 38 sec. The minimum distance between the ships was 6.5 km, and the first space meeting occurred on this flight.

"Vostok-3" and "Vostok-4" were put into orbit around the earth by multistage rocket-carriers, each having six liquid rocket engines with a total maximum thrust of 600,000 kg (engines of all stages, for each rocket).

TABLE 5. "Kosmos" series of artificial earth satellites.

Accepted name and international designation	Date of launching (1962)	Initial orbital data: perigee, km	apogee, km	Period of revolution about the earth, min	Angle of inclination of orbital plane to plane of terrestrial equator	Accepted name and international designation	Date of launching (1962)	Initial orbital data: perigee, km	apogee, km	Period of revolution about the earth, min	Angle of inclination of orbital plane to plane of terrestrial equator
"Kosmos-1"[1] 1962-θ	16 March	217	980	96.35	49°	"Kosmos-7"[7] 1962-	28 July	210	369	90.1	65°
"Kosmos-2"[2] 1962 ι	6 April	213	1560	102.5	49	"Kosmos-8"[8] 1962-	18 August	256	604	92.93	49
"Kosmos-3"[3] 1962-γ	24 April	229	720	93.8	48°59'	"Kosmos-9"[9] 1962-	27 September	301	353	90.9	65
"Kosmos-4"[4] 1962-ξ	26 April	298	330	90.6	65	"Kosmos-10"[10] 1962-	17 October	210	380	90.2	65
"Kosmos-5"[5] 1962-υ	28 May	203	1600	102.75	49°04	"Kosmos-11"[11] 1962-	20 October	245	921	96.1	49
"Kosmos-6"[6] 1962-αδ	30 June	274	360	90.6	49	"Kosmos-12"[12] 1962-	22 December	211	405	90.45	65

[1] On the satellite were installed scientific apparatus for study of the upper layers of the atmosphere and of outer space; a radio telemetric system and a radio transmitter (a two-channel radio station), operating on two coherent waves, according to more precise data, with frequencies of 20,005 and 90,0225 Mc, the second being exactly 4.5 times the first. The signal duration was about 4 sec, and that of the pauses, 0.5 sec. The last stage of the rocket-carrier also went into an orbit, close to that of the satellite.

[2] On the satellite were installed scientific apparatus, a multi-channel radio telemetric system and electronic instruments for trajectory measurement, and a shortwave "Mayak-2" transmitter operating on 2 coherent waves with frequencies of 20.005 and 90.0225 Mc. The signal duration was 2 sec, and that of the pauses, 0.5 sec. According to preliminary data, the satellite entered an orbit which differed only slightly from that calculated. Trajectory measurements on 7 April, 1962 showed the satellite's period of revolution about the earth to be 102.25 min, and its minimum and maximum distances from the earth, 211.6 and 1545.6 km, respectively.

[3] Installed on the satellite were scientific apparatus, a multi-channel radio telemetric system and electronic instruments for trajectory measurement. According to preliminary data, the satellite entered an orbit close to that calculated.

[4] Installed on the satellite were scientific apparatus, a "Signal" radio transmitter, operating on a frequency of 19.995 Mc, radio systems for precise measurement of orbit characteristics, and radio telemetric equipment for transmission to the earth of information about the functioning of the instruments and scientific apparatus installed on the satellite. When the program of scientific study was completed on 29 April, 1962, the satellite successfully landed, in accord with a command from earth, at a designated location in Soviet territory. "Vostok-4" was in orbit more than three days, during which it covered more than 2 million km, and its launching provided valuable scientific data.

[5] Installed on the satellite were scientific apparatus; a multi-channel radio telemetric system and electronic instruments for trajectory measurement; and a shortwave "Mayak" transmitter, operating on a frequency of 20.008 Mc. Preliminary data indicated that the satellite entered an orbit only slightly different from that calculated.

[6] Installed on the satellite were scientific apparatus; a multi-channel radio telemetric system and electronic instruments for trajectory measurement; and a shortwave "Mayak" transmitter, operating on a frequency of 90.0233 Mc.

[7] Installed on the satellite were scientific apparatus; a radio transmitter operating on a frequency of 19.994 Mc; a radio system for precise measurement of orbit parameters; and radio telemetric apparatus for transmission to earth of data on the functioning of the instruments and scientific apparatus on board.

[8] Installed on the satellite were scientific apparatus; a multi-channel radio telemetric system and electronic instruments for trajectory measurement; and a "Mayak" transmitter operating on frequencies of 20.00504 and 90.02268 Mc.

[9] Installed on the satellite were scientific apparatus; a radio transmitter operating on a frequency of 19.994 Mc; a radio system for precise measurement of orbit parameters; and a radio telemetric system for transmission to earth of data on the functioning of the instruments and scientific apparatus.

[10] Installed on the satellite were scientific apparatus; a radio transmitter operating on a frequency of 19.995 Mc; a radio system for precise measurement of orbit parameters; and a radio telemetric system for transmission to earth of data on the functioning of the instruments and scientific apparatus.

[11] Installed on the satellite were scientific apparatus; a multi-channel radio telemetric system and electronic instruments for trajectory measurement; and a shortwave transmitter operating on frequencies of 20.0048 and 90.0126 Mc. Preliminary data indicated that the satellite entered an orbit only slightly different from that calculated.

[12] Installed on the satellite were scientific apparatus; a radio transmitter operating on a frequency of 19.995 Mc; a radio system for precise measurement of orbit parameters; and a radio telemetric system for transmission to earth of data on the functioning of the instruments and scientific apparatus.

Bibliography

1. Programma issledovanii pri pomoshchi raket i iskusstvennykh sputnikov Zemli, namechennykh Sovetskim Soyuzom k provedeniyu v techenie MGG (The Program of Research Using Rockets and Artificial Earth Satellites Projected by the Soviet Union for the IGY). — Information Bulletin "Mezhdunarodnyi geofizicheskii god", No. 3. Izdatel'stvo AN SSSR. 1957.
2. Put' v kosmos (The Way to Space). Excerpts from "Pravda" about the three Soviet artificial earth satellites.—Moskva, Izdatel'stvo "Pravda". 1958.
3. Collection "Predvaritel'nye itogi nauchnykh issledovanii s pomoshch'yu pervykh sovetskikh iskusstvennykh sputnikov Zemli i raket" (Preliminary Reports of the Scientific Research Using the First Soviet Artificial Earth-Satellites and Rockets), No. 1. —Izdatel'stvo AN SSSR. 1958.
4. Khrgian, A.Kh. Geofizicheskie nablyudeniya, osushchestvlyaemye pri pomoshchi iskusstvennykh sputnikov Zemli (Geophysical Observations Performed with Artificial Earth Satellites).—Information Bulletin "Mezhdunarodnyi geofizicheskii god", No. 4. Izdatel'stvo AN SSSR. 1958.
5. Collection "Iskusstvennye sputniki Zemli" (Artificial Earth Satellites), issues 1 to 14.—Izdatel'stvo AN SSSR. 1958-1962.
6. "Byulleten' stantsii opticheskogo nablyudeniya iskusstvennykh sputnikov Zemli" (Bulletin of the Station for Optical Observation of Artificial Earth Satellites), Nos. 1 to 27. 1958-1962. (Rotaprint Astron. sovet AN SSSR).
7. Byull. "Rezul'taty nablyudenii sovetskikh iskusstvennykh sputnikov Zemli" (Results of Observations of the Soviet Artificial Earth Satellites, Bulletin), Nos. 1 to 54. 1958-1962. (Rotaprint Institut teor. astronomii AN SSSR Astron. sovet AN SSSR).
8. Pervye fotografii obratnoi storony Luny (The First Photographs of the Other Side of the Moon). Izd-vo AN SSSR. 1959.
9. Besprimernyi nauchnyi podvig (An Unprecendented Scientific Exploit). Excerpts from "Pravda" about the three Soviet space rockets.— Fizmatgiz. 1959.
10. Blagonravov, A.A. and M.G. Kroshkin. Geofizicheskie issledovaniya s pomoshch'yu raket i iskusstvennykh sputnikov (Geophysical Research Using Rockets and Artificial Satellites).— Vestnik AN SSSR, No. 7. 1960.
11. Collection "Stantsii v kosmose" (Stations in Space).— Izd-vo AN SSSR. 1960.
12. Vtoroi sovetskii kosmicheskii korabl' (The Second Soviet Spaceship).— Excerpts from "Pravda". Izd-vo "Pravda". 1960.
13. Informatsiya Sovetskogo komiteta MGG o vylpolnenii programmy raketnykh issledovanii verkhnei atmosfery v osnovnoi period MGG (1957-1958 gg.) (Information of the Soviet IGY Committee About

Completion of the Program of Rocket Research on the Upper Atmosphere during the Basic Period of the IGY (1957-1958).— Inform. byull. "Mezhdunarodnyi geofizicheskii god". No. 8, Izd-vo AN SSSR. 1960.
14. Atlas obratnoi storony Luny. Obrazovaniya, vyyavlennye na obratnoi storone Luny po fotografiyam, poluchennym avtomaticheskoi mezhplanetnoi stantsiei 7 oktyabrya 1959 g. (Atlas of the Other Side of the Moon. Formations Revealed on the Far Side of the Moon by Photographs Obtained by the Automatic Interplanetary Station on 7 October, 1959).— Izd-vo AN SSSR. 1960.
15. Aleksandrov, S.G. and R.E. Fedorov. Sovetskie sputniki i kosmicheskie korabli (Soviet Satellites and Spaceships). 2nd edition.— Izd-vo AN SSSR. 1961.
16. Pervyi polet cheloveka v kosmos (The First Manned Space Flight). Excerpts from "Pravda".— Izd-vo "Pravda". 1961.
17. Sovetskii chelovek v kosmose (A Soviet in Space). "Isvestii" Library. Special Issue.— Izd-vo "Izvestiya". 1961.
18. Gagarin, Yu. Doroga v kosmos (The Road to Space). Notes of the Soviet Astronaut.— Moskva. Voenizdat. 1961.
19. 25 chasov v kosmicheskom polete (Twenty-five Hours of Space Flight). Excerpts from "Pravda". Izd-vo "Pravda". 1961.
20. Titov, G. 700,000 kilometrov v kosmose (Seven Hundred Thousand Kilometers in Space). Narrated by the Soviet Astronaut.— Izd-vo "Pravda". 1961.
21. Pervye kosmicheskie polėty cheloveka. Mediko-biologischeskie issledovaniya (nauchnye rezul'taty mediko-biologicheskikh issledovanii vo vremya orbital'nykh poletov korablei-sputnikov "Vostok-1" i "Vostok-2") (The First Manned Space Flights. Medical and Biological Research (the Scientific Results of Medical and Biological Research During Orbital Flight of the Satellite-Ships "Vostok-1" and "Vostok-2")). Edited by N.M. Sisakyan (AN SSSR) and Professor V.I. Yazdovskii.— Izd-vo AN SSSR. 1961.
22. Utro kosmicheskoi ery (The Dawn of the Space Age).— Gispolitizdat. 1961.
23. Novyi polet v kosmos (Recent Space Flight). Voenizdat. 1961.
24. Molchanova, N.S., A.Ya. Chernyak, and Z.P. Shalashova. Sovetskii narod-pobeditel' kosmosa. Rekomendyemi obzor literatury (The Soviet People — Conquerors of Space. Recommended Survey of the Literature). Ministerstvo kul'tury RSFSR, Gosudarstvennaya ordena Lenina biblioteka SSSR im. V.I. Lenina.— Moskva. 1961.
25. Kratkie dannye o sovetskikh iskusstvennykh sputnikakh Zemli, kosmicheskikh korablyakh-sputnikakh i kosmicheskikh raketakh (Concise Data on Soviet Artificial Earth Satellites, Satellite-Spaceships, and Space Rockets).— Collection "Iskusstvennye sputniki Zemli", No. 12. Izd-vo AN SSSR. 1962.
26. V kosmose dvoe (Two in Space). Biblioteka "Izvestii". Special issue. Izd-vo "Izvestiya". 1962.
27. Pervyi v mire gruppovoi polet v kosmicheskoe prostranstvo. Osnovnye itogi (The World's First Group Flight to Outer Space. Basic Results).— "Pravda", 22 October, 1962. No. 295 (16151).
28. Press Conference Devoted to the Flight of Andriyan Nikolsev and Pavel Popovich.— "Pravda", 22 October, 1962. No. 234 (16090).

29, Gerd, M.A. and N.N. Gurovskii. Pervye kosmonauty i pervye razvedchiki kosmosa (The First Astronauts and Prospectors of Space).— Izd-vo AN SSSR. 1962.
30. Gal'perin, Yu. and T. Mulyarchik. Sputniki, atmosfera i elektrony (Satellites, the Atmosphere, and Electrons).— "Pravda", 26 September, 1962. No.269 (16125).
31. Kosmos i progress chelovechestva. Beseda s Prezidentom Akademii nauk SSSR akademikom M.V. Keldyshem (Space and Human Progress. Conversation with the President of the Academy of Sciences of the USSR M.V. Keldysh).— "Pravda", 4 October, 1962. No.277 (16133).
32. A'eksandrov, S.G. O nauchnykh itogakh issledovaniya kosmicheskogo prostranstva (The Scientific Results of the Investigation of Outer Space).— "Pravda", 4 October, 1962. No.277 (16133).
33. Kroshkin, M.G. and V.G. Samarin. Obmen cherez Mirovoi tsentr dannykh B materialami, poluchennymi pri pomoshchi raket i sputnikov (Exchange through World Data Center B of Materials Obtained Using Rockets and Satellites).— Geofiz. byull. No.12. Izd-vo AN SSSR. 1962.
34. Katalog dannykh po raketam i sputnikam (1957-1962), ch. I Perechen' materialov po raketam i sputnikam (na russkom yazyke), imeyushchikhsya v Mirovom tsentre dannykh B (sostaviteli — M.G. Kroshkin, V.G. Samarin i R.B. Rubinshtein) (Catalog of Rocket and Satellite Data (1957-1962), No.I. Inventory, compiled by M.G. Kroshkin, V.G. Samarin, and R.B. Rubinshtein, of literature on rockets and satellites (in Russian) at World Data Center B). Mirovoi tsentr dannykh B, USSR.— Moskva. 1962.
35. Problemy kosmicheskoi biologii, t.1. (Problems of Space Biology, Vol.I). Edited by N.M. Sisakyan (AN SSSR).— Izd-vo AN SSSR. 1962.
36. Petrov, E. Kosmonavty (Astronauts). Zapiski rukovoditelya gruppy (Notes of Group Leader).— Izd-vo "Sovetskaya Rossiya". 1962.
37. Pervyi gruppovoi kosmicheskii polet (The First Group Space Flight).— Voenizdat. 1962.
38. Zemlya — kosmos — Zemlya (Earth — Space — Earth). Excerpts from "Pravda".— Izd-vo "Pravda". 1962.
39. Skuridin, G.A. Kosmicheskaya fizika (Space Physics).— Priroda, No.1. 1963.
40. Blagonravov, A.A. Report on Space Research in the USSR.— COSPAR, Inform. Bull., No.6 (Special Issue). September 1961, pp.123-134.
41. Blagonravov, A.A. National Report of the USSR Academy of Sciences on the Investigations of Outer Space Carried Out in the Soviet Union in 1961.— COSPAR, Inform. Bull. No.11 (Special Issue). September 1962, pp.93-106.

D. L. Finger

CONFERENCE ON STUDY OF THE EARTH'S MAGNETIC FIELD IN THE WORLD OCEAN

On 17-18 April, 1962 a broadened conference of the Section for Geomagnetism and Earth Currents of the Interdepartmental Committee was held in Izmiran. Representatives of 20 organizations participated in the conference, which dealt with problems arising in study of the earth's magnetic field in the World Ocean, and its papers were read.

The conference was opened by the President of the Section, Yu. D. Kalinin (Dr. Phys. Math. Sci.). He pointed out that since 1957 the Soviet Union had been making a systematic survey of the earth's magnetic field in the oceans from the nonmagnetic ship "Zarya." The results have revealed errors in world maps and the consequent need to improve their accuracy.

The magnetic surveying of the oceans done outside the Soviet Union from airplanes and using magnetometers towed behind iron ships is well known, and the use of towed magnetometers has also been begun in the Soviet Union. The aim of the Conference was to summarize the work already done in magnetic measurement on the oceans, and to coordinate its expansion and development by all interested agencies. This would require coordination of the activities of the organizations of various ministries.

V. P. Orlov (Cand. Phys. Math. Sci.) (Izmiran) reported on the plan for a world magnetic survey. World magnetic maps are necessary to give a correct representation of the magnetic field distribution over the earth's surface, to reveal the basic laws of geological structure, which are connected with the magnetic field and to perform a more precise potential analysis. At present, for a considerable part of the earth's surface, no sufficiently precise maps are available. At the sessions of the Special IGY and the International Committee on Geophysics, the question of carrying out a world magnetic survey was raised and it was decided to make such a survey, to be used as a basis for the compilation of world magnetic maps, during the period of minimum solar activity. Orlov emphasized the necessity of studying the secular variation of the geomagnetic field.

M. M. Ivanov (Izmiran, Cand. Phys. Math. Sci.), the leader of several expeditions of the "Zarya," reported on the accuracy of magnetic maps and on secular variation of the magnetic field on the oceans. He pointed out that evaluation of the accuracy with which maps can be constructed from existing magnetic data for the oceans is largely determined by the neglected magnetic field anomaly, which he used to show the error of mapping can be no less than 300-400 g along both horizontal and vertical field components, or 1° to 2° of inclination.

The error in existing maps was evaluated by comparing maps for 1955 in the USSR, U.S.A., and England with the data gathered by the "Zarya."

Wide regions of systematic error, as high as 2000 in the horizontal and vertical field components, or 6° of declination, were revealed. In order to minimize such errors the network of observation routes must be made much denser and the secular variation must be systematically observed.

M. M. Ivanov reported on the results of magnetic measurements made from the "Zarya," briefly described her itineraries between 1957 and 1961, and dwelt in greater detail on the measurements in the Atlantic Ocean and on comparison of the results obtained with geology.

D. L. Finger (Izmiran, Cand. Phys. Math. Sci.) reported on magnetic measurements on the sea using magnetometers towed by iron ships. The magnetic measurements were carried out, with the ship in motion, by distance magnetometers, whose sensors were towed in specially designed stabilized nonmagnetic "birds," outside the magnetic field of the ship. Magnetometer models with magnetically-saturated detectors were used to measure the vertical component Z and the modulus of the total force vector T, while proton magnetometers were used to measure T itself.

Finger also briefly discussed the results and errors of the measurements. The results of measuring Z and T in a uniform magnetic field and in a region of anomaly show that the apparatus is of sufficient reliability for use in sea surveys. For measurements on the oceans the magnetometers and "birds" must be modernized.

T. N. Simonenko (VSEGEI, Dr. Phys. Math. Sci.) reported on the significance of the magnetic survey of the oceans. She compared the character of the magnetic field anomaly for continental and oceanic types of the earth's crust and determined their common features and differences. From studies of the magnetic field along abyssal seismic sounding profiles in the USSR she established that the depth of bedding and thickness of the basalt layer of the crust do not affect the magnetic field intensity. From this she concluded that the magnetic anomalies of the ocean floor are produced by thermomagnetization during the effusion of subcrustal matter which intruded into the basaltic layer, and that study of the magnetic anomalies of the ocean may be of assistance in studying the oceanic crust.

The paper of the senior geophysicist, O. N. Solov'ev (VNIIGeofizika), on the "Abyssal geological structure of the transitional zone between the continent of Asia and the Pacific Ocean in the region of the Kuril-Kamchatka island arc" was read by the chief geophysicist of VNIIGeofizika, S. G. Popov. The paper gave an account of the methods and the results of the aeromagnetic survey of the transitional zone from Asia and the Pacific Ocean, with an examination of the principal anomalies. The peculiarities of the anomalous magnetic field were shown and related to the geological structure. The results of comparing maps of magnetic anomalies with gravimetric data were cited, and it was shown that the magnetic anomalies are connected with zones of major stresses and fractures.

I. M. Pudovkin (IZMIRAN, Cand. Phys. Math. Sci.) presented a review of magnetic surveys on the oceans and world magnetic maps. After analyzing the errors of the magnetic maps, he emphasized the necessity of improving their accuracy.

B. M. Matveev (IZMIRAN), the head of the "Zarya" expedition, reported on the preliminary results of a magnetic survey in the Pacific Ocean, and discussed the scientific equipment of the "Zarya."

Sh. Sh. Dolginov (Cand. Phys. Math. Sci.) read a paper on the present state of magnetic measurement techniques.

A report on some results of the aeromagnetic survey over the polar seas was read by R. M. Demenitskaya (NIIGAiK, Dr. Geol. Mineral. Sci.).

The chief geophysicist of VNIIGeofizika, S. G. Popov, reported on marine research with a nuclear magnetometer. The nuclear magnetometer developed at VNIIGeophysics was tested on the sea in a "bird" developed at IZMIRAN. At present plexiglas "birds" are being developed at VNIIGeophysics.

N. D. Medvedev (IZMIRAN), a member of the Antarctic expeditions, reported on magnetic measurements in the Antarctic.

A. P. Shlyakhtina (IZMIRAN) reported on magnetic maps of the Antarctic for 1960, which were compiled from the data of both Soviet and other scientists.

A paper on the present state of gravimetric measurements on the ocean was read by Yu. D. Bulanzhe (IFZAN, Dr. Phys. Math. Sci.).

The paper prepared by I. P. Kosminskaya (Cand. Phys. Math. Sci.) and S. M. Zverev (Cand. Geol. Mineral. Sci., IFZAN) on "The present state of seismic measurements on the ocean" was read by S. M. Zverev.

There followed a discussion in which 26 people participated. The great importance of studying the distribution of the earth's magnetic field over the water surface was emphasized, since water covers over two-thirds of the earth's surface, and is the part whose magnetism has been least studied.

More accurate magnetic maps of the earth are necessary for sea and air navigation, for the compilation of general maps of normal fields, the isolation of magnetic anomalies, the study of ocean currents by the electromagnetic method, the analysis and interpretation of magnetic observations made by rockets and satellites in space, etc.

The necessity of studying the secular variation, in order to reduce magnetic observations to a single period and investigate the causes of secular variations was also mentioned; the results obtained could subsequently be used in forecasting the secular variation.

The desirability of comprehensive geophysical research was also mentioned. This would entail simultaneous seismic, gravimetric, and magnetic observations, as well as systematic study of the ocean floor and the earth's crust, using bathyscapes.

The conference approved the magnetic survey of the oceans carried out by the schooner "Zarya," approved designs for towed magnetometers and formally recognized the need to broaden and accelerate this research in every possible way.

The conference noted that the magnetic survey of the oceans is a problem of national importance. The survey must be systematic and uniform, and to accomplish this requires the cooperation of various ministries and departments. Research on the oceans requires comprehensive geological and geophysical methods. A number of concrete proposals for solution of the problem were accepted by the conference.

V. M. Kotlyakov

THE SECOND ALL-UNION GLACIOLOGICAL SYMPOSIUM

The first all-union conference of glaciologists, devoted to presentation of the overall glaciological results of the IGY, took place in January, 1961. One of the scientific symposia at this conference considered a most important glaciological problem, the material balance and variations in the behavior of existing glaciers. However, at that time scientists were only beginning to familiarize themselves with the IGY data and all the aspects of this problem could not be evaluated.

In order to evaluate the results and directions of subsequent research on variations in the behavior of glaciers the Glaciology Section of the Geophysics Committee of the Presidium of AN SSSR and the Glaciology Division of the AN KazSSR held the Second All-Union Glaciological Symposium at Alma-Ata, from 25 June to 5 July, 1962. About 100 glaciologists and meteorologists, representing the institutes of AN SSSR and of allied republics, as well as several universities and hydrometeorological institutes, participated.

Modern glaciology cannot develop successfully without simultaneous and coordinated observations on the state of glaciers in different regions of the globe, since the laws of glaciation on the earth have a global character. Several problems of glaciology, which are of first-order importance for the earth sciences and the national economy, are still unsolved, since the observations made during the IGY turned out to be insufficiently protracted for an understanding of the general tendencies of recent glaciation. Next in line is the prediction of the future behavior of glaciers, and for this the reasons for differences in their behavior in analogous climatic conditions and the connection between the changes in glaciers and other geophysical factors must be thoroughly elucidated.

All these problems can be solved only by using data on glacier variation in all the regions of the globe, i. e., on the basis of international observations. A resolution on the necessity of systematic international observations of variations in existing glaciers was taken by the Snow and Ice Commission at the Twelfth General Assembly of the IQSY, which took place at Helsinki in August, 1960. G. A. Avsyuk, the Chairman of the Glaciology Section, spoke of the development of a concrete plan for such observations in the Soviet Union at the Alma-Ata symposium /1/. Observations of more than 300 glaciers, involving the combined efforts of 19 Soviet scientific institutions and universities are envisaged over the course of 20 years. The glacier stations will all be divided into two classes: those for annual and those for quinquennial observations.

Broad international observations contribute much that is new to science. Already interesting data have been obtained and ingenious hypotheses about the laws of glacier variation have been advanced. The theory of P. A. Shumskii /2/, according to which both stability of motion and invariance of external conditions are required for maintenance of a stationary state, was reported at the Alma-Ata symposium. The reasons for glacier oscillation are changes in conditions at the boundaries of the glacier (velocity of mass exchange, temperature, stress tensor, and slope of bed).

A system of equations of state for an unstable glacier has been derived from the equation of continuity of an unstable glacier, the equation of dynamic equilibrium, and the rheological equation of state. The inevitability of a reaction of the entire glacier to changes in any of its parts, including the tip of the glacier, follows from these equations, in contrast to the theory of kinematic waves, according to which changes can be propagated only from top to bottom of the glacier.

The equations of state constitute a nonlinear system of third order partial differential equations which cannot be squared and can be solved only by approximate methods. Application of these methods to the retreating ice cap of Drygalski Island (Antarctica) made it possible to determine changes in the velocity, thickness, and position of the edge of the cap with time, the period of time necessary for restoration of a stable state, assuming stability of external conditions, the dimensions of the cap, and the ice-velocity field in the new stable state.

The equation of state permits calculation of the rapidity and time of changes, the dimensions of the glacier, and the ice-velocity field in the new stable state to which the glacier, brought out of its known previous stable state by any given sudden change in external conditions, tends. The speed of changes in the dimensions of the glacier and in the velocity of the ice, resulting from the loss of stability through change of the external conditions, can also be calculated.

V. M. Kotlyakov's paper /3/ gave four reasons for the recent tendency to the development of glaciation on the globe: (1) the distribution of glaciers in the northern or southern hemisphere; (2) the trend of secular climatic change; (3) less protracted climatic variations, connected with change in the forms of atmospheric circulation; (4) the dimensions of glaciers, as well as their lateral and altitudinal position. At present the Antarctic ice sheet, because of its enormous size and circumpolar location in the southern hemisphere, is in favourable conditions for development and evidently close to a state of equilibrium; if it does shrink, the rate of shrinkage will be at least an order less than that of other terrestrial glaciers.

According to the calculations of P. A. Shumskii, in cold glaciers an increase in the temperature of the ice results in acceleration of motion and decrease in thickness. In this case the extremities of glaciers usually recede; the tips of glaciers submerged in water as far as the line of hydrostatic equilibrium always recede. With the increase in warmth and humidity of the Antarctic climate (presently being observed), an increase of 1° in the ice temperature leads to decrease of the thickness of the Antarctic ice cover at a rate balancing the increase in the rate of atmospheric precipitation, which averages several dozen millimeters of water per year. Warming must decrease the thickness and cause the edge of the Antarctic ice cover to recede. However, there was evidently no correspondence in the development of the Antarctic and other glaciers throughout the Quaternary Period, as the full degradation of the ancient ice-shields of the northern hemisphere and the comparatively small change in the Antarctic ice cover over the same period testify. Glaciation on the earth is therefore synchronous only in geological time.

In speaking of short periods of time in one or several decades, it should be emphasized that the development of glaciers in different regions of the globe can not only proceed at different rates, but in opposite directions. This is explained by regional differences in the manifestations of separate forms of the general atmospheric circulation. Thus, according to M. Kh. Baidal /4/, the eras of retreat of alpine glaciers are characterized by a tendency to the advance of altaic glaciers and vice versa. A.N. Krenke's studies /5/ have shown that the development tendencies of the glaciers of the Canadian archipelago and of the Barents Sea are opposed. This is confirmed even by comparison of ablation measurements on the glaciers of both regions in 1958 and 1959. Consequently, short-term variations in glaciers are not globally synchronized.

Features of the fluctuation of glaciation in Novaya Zemlya during the twentieth century were discussed in the lectures of O. P. Chizhov, V. S. Koryakin /6/, and N. V. Davidovich /7/, while M. G. Grosval'd /8/ reviewed the history of glaciation in Franz Joseph Land during the late-glacial and post-glacial periods, using radiocarbon dating of three driftwood samples gathered from ancient marine terraces.

The report of I. A. Zotikev /9/ was devoted to thermophysical processes in the mass of thick glaciers, and contained an analytical expression making it possible to determine whether or not there is ice melting near the bed. Such melting is possible when there is a certain relationship between the thickness of the ice, the temperature near its surface, the rapidity with which precipitation is accumulated, and the magnitude of the geothermal heat flow. In Antarctica it occurs over an area of approximately 12,000,000 km^2, i. e., more than 80 % of the territory, though this melting actually forms only 20 km^3 of water per year, i. e., less than 1 % of the total yearly accumulation of ice in Antarctica.

A. P. Polosukhin, Vice-President of the AN KazSSR, and N. N. Pal'gov, Director of the Glaciology Division, pointed out the enormous scientific and practical significance of the problem of fluctuations of existing glaciers, especially in the regions of Central Asia, where glaciers are the principal sources of moisture for arid regions.

K. G. Makarevich presented in his report /10/ many facts concerning the retreat of the glaciers of the Trans-Ili Ala Tau in the twentieth century and pointed out the constant fluctuations in the course of this process. The dynamics of the glaciation of the Trans-Ili Ala Tau, according to V. A. Gerasimov /11/, are characterized by traces of two glaciations. P. A. Cherkasov /12/ predicts that in 1963-1965 the glaciers of Kazakhstan and Central Asia will undergo more notable shrinkage. The other reports of the glaciologists and climatologists of Kazakhstan linked glacier fluctuations over the past ten years with climatic variations and fluctuations in the levels of drainless lakes over the same period.

M. V. Tronov /13/ presented evidence for the retreat of glaciers in the Katun', North Chuya, and South Chuya ranges of the Altai between 1897 and 1960, emphasizing the indications and phenomena related to the dependence or independence of the climate on glacier fluctuations. In addition, he devoted detailed consideration to the effect of summer snows on glacier variation. Pointing out that for glaciological and climatological purposes it is insufficient to take into account only the highest seasonal level of the snow-line, he suggested consideration of the mean height of the snow-line in the summer or in the most active part of the period of ablation, with calculation of the two following factors:

a) the product of the mean height of the snow-line above the base of the glacier and the duration of the ablation period, and

b) the total area of bare ice on the glacier during the ablation period. Taking as examples the Central Tuyuksu glacier and the Trans-Ili Ala Tau, N. N. Pal'gov /14/ established the laws of glacier shrinkage as a function of the position of the firn line, using data gathered between 1937 and 1961.

Some papers were devoted to positive effects on glaciological processes. At present field experiments are in progress and theoretical foundations for artificial intensification of the melting of mountain glaciers, which is of great importance to the arid regions of Central Asia, are being developed. On the other hand, the possibilities of influencing frontal cloud systems with the goal of increasing the amount of solid atmospheric precipitation in glacier regions are also being studied.

Bibliography

All the articles listed below were published in the collections of the series "Materialy glyatsiologicheskikh issledovanii. Khronika. Obsuzhdeniya," Nos. 9 and 10.

1. Avsyuk, G. A. Obshchaya programma mezhdunarodnykh postoyannikh nablyudenii za kolebaniyami sovremennykh lednikov (General Program of Constant International Observations of Variation of Recent Glaciers), No. 9.
2. Shumskii, P. A. K teorii kolebanii lednikov (Contribution to a Theory of Glacier Variation), No. 10.
3. Kotlyakov, V. M. O prichinakh razlichnykh tendentsii razvitiya sushchestvuyushchikh lednikov (Reasons for Different Tendencies in the Development of Recent Glaciers), No. 10.
4. Baidal, M. Kh. Dinamika lednikov v svyazi s makrotsirkulyatsionnymi epokhami (The Dynamics of Glaciers and Epochs of Macrocirculation), No. 10.
5. Krenke, A. N. Raionirovanie lednikov Arktiki v svyazi c tsirkulyatsiei atmosfery (Regional Distribution of Glaciers of the Arctic in Connection with Atmospheric Circulation), No. 10.
6. Chizhov, O. P. and V. S. Koryakin. Sovremennye izmeneniya rezhima novozemel'skogo oledeneniya (Recent Changes in the Glaciation of Novaya Zemlya), No. 10.
7. Davidovich, N. V. O vozmozhnosti izmeneniya tipa pitaniya novozemel'skogo lednikovogo pokrova (The Possibility of a Change in the Alimentation of the Novaya Zemlya Ice Sheet), No. 10.
8. Grosval'd, M. G. Izmeneniya oledeneniya Zemli Frantsa-Iosifa za pozdnechetvertichnoe vremya (Changes in the Glacier of Franz Joseph Land During the Late Quaternary Period), No. 10.
9. Zotikov, I. A. Donnoe tayanie v tsentral'noi zone ledyanogo shchita Antarktidy i ego vliyanie na sovremennyi veshchestvennyi balans l'da (Bottom Melting in the Central Zone of the Antarctic Ice Shield and Its Influence on the Present Material Balance of the Ice), No. 10.

10. Makarevich, K. G. K voprosu o kolebaniyakh rezhima lednikov Zailiiskogo Alatau v poslednie desyatiletiya (On Fluctuations in the Behavior of the Glaciers of the Trans-Ili Ala Tau During the Past Ten Years), No. 9.
11. Gerasimov, V. A. Dinamika oledeneniya v pozdnechetvertichnoe vremya v Zailiiskom Alatau (The Dynamics of Glaciation in the Late Quaternary Period in the Trans-Ili Ala Tau), No. 9.
12. Cherkasov, P. A. Vnutrivekovaya tsiklichnost' izmeneniya prostranstvennogo sostoyaniya lednikov Kazakhstana i Srednei Azii (Cyclicity of Change in the Dimensional State of the Glaciers of Kazakhstan and Central Asia within One Century), No. 9.
13. Tronov, M. V. Kratkie svedeniya ob otstupanii lednikov Altaya. O priznakakh i proyavleniyakh podchinennosti i nepodchinennosti klimatu v kolebaniyakh lednikov (Concise Evidence for the Retreat of the Glaciers of the Altai. Indications and Phenomena Related to the Dependence or Independence of the Climate on Glacier Fluctuations), No. 9.
14. Pal'gov, N. N. Sokrashchenie lednikov v zavisimosti ot polozheniya firnovoi linii i obuslovlennye im zakonomernosti (na primere Tsentral'nogo Tuyuksuiskogo lednika) (Glacier Shrinkage as a Function of the Position of the Firn Line and the Laws Deriving from it (Taking as an Example the Central Tuyuksu Glacier)), No. 9.

INFORMATION

Soviet Union

On 12 October, 1962 the Council of Ministers of the USSR accepted a resolution to appoint E. K. Fedorov (Academician) Head of GUGMS of the Council of Ministers of the USSR.

On 13 February, 1963, by disposition of the Presidium of AN SSSR, A. P. Kapitsa, Candidate of Geographical Sciences and Director of the Laboratory of Moscow State University, was made a member of MGK and appointed its Vice President.

To replace P. K. Evseev, whose resignation was accepted at his request, V. F. Burkhanov, Chairman of the Working Commission on International Exchange of MGK, was appointed to MKG as lecturer from MTsD.

By disposition of the Presidium of AN SSSR, N. P. Lavrov (Reader and Candidate of Engineering Science) was appointed to MGK, effective 2 February, 1963.

In April, 1962 the Presidium of AN SSSR accepted a resolution to create, in Irkutsk, on the basis of the East-Siberian Geological Institute, an Institute of the Earth's Crust of the Siberian Division (SO) of AN SSSR. This new institute has sections of geology and geophysics with laboratories for tectonics and structural and geology, engineering seismology, magmatic and metamorphic formations, seismology, seismometry, geothermy, etc.

The fundamental direction of the institute's scientific activity is study of the laws of development of the structure and matter of the earth's crust, its present structure, and its exo- and endodynamic processes. This is made possible by the predominant development of research in the field of geophysical methods for study of the structure and dynamics of the earth's crust, seismology, magnetometry, gravimetry, geothermy, in the study of the exo- and endodynamics of the earth, petrology, and sedimentology.

Of the five Ph. D's and 35 Candidates of Sciences working at the Institute, the most prominent are N. A. Florensov (Corresponding Member of AN SSSR), M. M. Odintsov (Doctor of Geological and Mineralogical Sciences), V. P. Solonenko, I. V. Belov, and A. A. Tresov (Doctor of Physical and Mathematical Sciences). The director of the Institute is M. M. Odintsov.

On 7 July, 1962 the Presidium of AN SSSR decided to organize, in Petropavlovsk-on-Kamchatka, an Institute of Volcanology within SO AN SSSR. The Institute was organized on the base of the Kamchatka Geological and Geophysical Observatory and the Volcanology Laboratory of SO AN SSSR. B. I. Piip (Corresponding Member of AN SSSR) was appointed its director.

The Institute will be given a 400-500 ton ship equipped for research on submarine volcanism. Its fundamental task is the study of modern active volcanism on Kamchatka, as well as the study of Recent (Quaternary) volcanism in other regions of the country. It will also participate in the study of volcanism on the territory of other countries.

The Institute itself is organized into laboratories for superficial and subterranean volcanism, the interrelationship of surface and abyssal magmatism, the Kamchatka and Avachinskaya volcanic stations, laboratories for postmagmatic processes, hydrogeology, and geothermy, regional and volcanic geophysics, isotopic analysis and absolute growth, the Petropavlovsk ionosphere station, and other subdivisions.

(From Resolution No. 766 of the Presidium of AN SSSR,
7 September, 1962)

In accord with the resolution of 7 September, 1962 of the Presidium of AN SSSR, an Institute of Space Physics Research and Aeronomy was set up in YaFSO of AN SSSR. It is located in Yakutsk and based on the Laboratory for Physical Problems and Nontectonic Subdivisions of the Geophysical Observatory of YaFSO AN.

The basic directions of the Institute's research are: study of variations in the energy spectrum of primary cosmic rays, electromagnetic conditions near the earth, and spatial distribution of the geomagnetic field; study of the composition and spectrum of primary cosmic rays and their change during a cycle of solar activity, and the interrelationships between cosmic radiation and the earth's radiation belts; study of cosmic ray bursts and wide atmospheric cosmic ray showers; study of the physical characteristics of the polar auroras and the luminosity of the night sky; space-time laws in the distribution of the form, luminosity, and spectra of the polar auroras and the night sky; magnetic field variations; telluric and marine currents; ultralow-frequency radio waves to clarify the nature of the polar auroras and their connection with the earth's radiation belts; study of the properties of radio wave propagation in the polar regions, etc.

On 3 November, 1962 the Directorate of the Presidium of AN SSSR published a resolution on the state and prospects for the determination of the absolute age of geological formations, in which the necessity of broadening study in this area was indicated.

The Commission on the Determination of Absolute Age is obliged to publish quarterly (at the times of international geological congresses) a precise scale of absolute geological chronology. The division of geological and geographical sciences and the Publishing House of AN SSSR must publish the papers of the Commission's annual sessions.

The Commission's international ties should be strengthened to coordinate geochronological studies in neighboring territories. The establishment of permenent close contact with the Commission for Determination of the Absolute Age of Geological Formations of the Carpatho-Balkan Geological Association (whose President is the Academician N. P. Semenenko) was proposed, as well as association with the Scientific Council of AN SSSR on the complex problem of the "Structure and Development of the Earth" (President M. A. Sadovskii, Corresponding Member of AN SSSR).

G. D. Afanas'ev (Corresponding Member of AN SSSR) is head of the Commission's Directorate.

MGK sent telegrams announcing the launching of the "Kosmos" (Kosmos-6 and Kosmos-11) and "Vostok" (Vostok-3 and Vostok-4) satellite launchings to addresses outside the Soviet Union. Details of the satellites are given in the article of M. G. Kroshkin and V. G. Samarin, which is included in this collection.

On the territory of the Odessa Geomagnetic Laboratory of the L'vov branch of the Institute of Geophysics of AN SSSR continuous recording of daily variations and ripples in earth currents and in the time product of ripples in the vertical component of the geomagnetic field has been arranged. The daily variations are recorded by a standard instrument with a time sweep of 22 mm/hour. The ripples in earth currents and in the geomagnetic field are registered by seismic recorders with a sweep of 30 mm/min and an adjustable screw of pitch 5 mm.

The instrument for measurement of the geomagnetic field consists of an induction loop of effective area $59.4 \times 10^4\,m^2$ and a highly sensitive mirror galvanometer whose loop vibrations have a natural frequency of period 0.1 sec. Recording of the earth currents was begun in April, 1961 and of the geomagnetic field, in July, 1962.

The expeditionary group of the physics faculty of MGU under the direction of G. I. Kuznetsov carried out ozonometric observations in the Black and Mediterranean Seas and in the Atlantic Ocean during a voyage of the training ship "Baltiisk" from Odessa to Murmansk in November and December, 1962. The expeditionary shipside observations of atmospheric ozone made it possible to trace the influence of various synoptic processes under different geographic conditions.

A sharp increase (from 0.250 to 0.329 cm) of the ozone content in the atmosphere was noted between 10 and 12 November, when the ship was abeam Bizerta. This was accompanied by a powerful intrusion of arctic air into the southern regions of France. A second intrusion with an increase in ozone from 0.253 to 0.310 cm, was noted in the region of Casablanca between 19 and 23 November.

An all-union symposium on "Variations in existing glaciers," convened by the Committee together with AN Kazakh. SSR, took place at Alma-Ata from 25 June to 5 July, 1962. A total of 88 scientists, representing 31 institutions, participated in the symposium and the expanded conference of the glaciological section, timed to coincide with it. Forty-five lectures, devoted for the most part to the results of the IGY, were given.

Changes in the glaciers of Central Asia, Altai, the Caucasus, and other regions of the USSR, as well as in the glaciers of the Antarctic, were characterized. A great deal of attention was given to the establishment of correlations between changes in the atmospheric circulation and variations in glaciers, the reactions of different types of glaciers to climatic changes connected with the change of the glaciers themselves, the physics of thermal mass exchange between glaciers and the atmosphere, and the general physical and mathematical theory of changes in the dimensions, form, and variation cycle of glaciers, under the influence of an external medium.

The need to intensify work on the analysis of the physical processes determining changes in glaciers, and on the numerical analysis of glaciological data and in other directions anticipated, was recognized. The insufficient attention devoted to generalization and analysis of the planetary data reaching MTsD was pointed out.

The participation of Soviet glaciologists in continuous observations of the fluctuations in existing glaciers, as part of the international program adopted in the autumn of 1962 at the Ober Gurgl (Austria) meeting of the International Commission on Snow and Ice, was considered. This program envisages simultaneous coordinated glaciological observations on a global scale. Decisions were taken about the scale for compilation of a Catalog of Glaciers of the USSR, about preparations for the first all-union Conference on the results of the IGY, and about the presentation of lectures and reports for the Thirteenth General Assembly of IGGU. The participants of the symposium noted the model work of the Organizing Commission of the Glaciological Section of the AN KazSSR in preparing and conducting the symposium.

The all-union Conference on the direction of research on cosmic rays, convened by the Scientific Council on the problem of "Cosmic Rays" and SO AN SSSR, took place in Yakutsk between 23 August and 2 September, 1962. More than 150 scientists, representing more than 30 scientific institutions, participated.

Among the problems considered were variations in cosmic rays of various types, the origin of cosmic rays, the composition and properties of the primary component and of the earth's radiation belts, ionospheric phenomena, and the relation of the physics of cosmic rays to geophysics and astrophysics. In addition to original lectures, which numbered more than 50, on separate aspects of these problems, survey lectures were given by V. L. Ginzburg (the origin of cosmic rays), B. M. Pontecorvo (physics of the neutrino), N. L. Grigorov (nuclear interactions), D. S. Chernavskii (theory of nuclear interactions), S. I. Nikol'skii (extensive air showers), Ya. I. Smorodinskii (the neutrino and cosmogony), L. I. Dorman (variations in cosmic rays), Yu. G. Shafer (rocket and satellite research), and A. I. Kuz'min (cosmic ray bursts).

A combined meeting of the Scientific Council on the problem of "Cosmic Rays" and the Cosmic Ray Section of MGK took place in Yakutsk on 30 September, 1962. Plans for the physical study of cosmic rays, the program of research during the IYQS, and a number of organizational matters were discussed.

The following Committee publications were issued in the series "Results of the IGY."

1. Polyarnye siyaniya i svechenie nochnogo neba. Sbornik statei No. 9. Otv. red. V.I. Krasovskii (The Polar Auroras and Luminosity of the Night Sky. Collection of Articles No. 9, ed. V.I. Krasovskii).

2. Nazarov, V.S. L'dy Antarkticheskikh vod. Okeanologiya, No. 6. Otv. red. V.L. Tsyrikov, I.M. Belousov (The Ice of Antarctic Waters. Oceanology, No. 6, ed. V.L. Tsyrikov and I.M. Belousov). The paper gives the characteristic properties of the ice and the features of its formation and disintegration. Questions of balance and variability of ice are also discussed, and ice maps are included.

3. Mezhdunarodnyi geofizicheskii god. Bibliograficheskii ukazatel' na russkom yazyke za 1961 g. Otv. red. B.I. Silkin (The International Geophysical Year. A Bibliographical Index of Works in Russian for 1961, ed. B.I. Silkin).

4. Issledovaniya po klimatologii serebristykh oblakov. Meteorologiya, No. 6. Otv. red. I.A. Khvostikov (Research on the Climatology of Noctilucent Clouds. Meteorology, No. 6, ed. I.A. Khvostikov).

5. Fel'shtein, Ya.I. Prostranstvenno-vremennoe raspredelenie magnitnoi aktivnosti v vysokikh shirotakh severnogo polushariya (Space-time Distribution of Magnetic Activity in the High Latitudes of the Northern Hemisphere), Geomagnetism, No. 5, ed. B.A. Bagaryatskii.

6. Kosmicheskie luchi. Sbornik statei No. 5. Otv. red. S.N. Vernov, L.I. Dorman (Cosmic Rays. Collection of Articles No. 5, ed. S.N. Vernov and L.I. Dorman).

7. Glyatsiologicheskie issledovaniya. Sbornik statei No. 9. Otv. red. G.A. Avsyuk (Glaciological Research. Collection of Articles No. 9, ed. G.A. Avsyuk).

8. Borovinskii, B.A. Izuchenie lednikov Zailiiskogo Alatau geofizicheskimi metodami (Study of the Glaciers of the Trans-Ili Ala Tau by Geophysical Methods). Glyatsiologiya, No. 10, ed. G.A. Avsyuk.

9. Okeanologicheskie issledovaniya. Sbornik statei No. 7. Otv. red. I.M. Belousov (Oceanological Research. Collection of Articles No. 7, ed. I.M. Belousov).

10. Okeanologicheskie issledovaniya. Sbornik statei No. 8. Otv. red. N.N. Sysoev and N.M. Kozlov (Oceanological Research. Collection of Articles No. 8, ed. N.N. Sysoev and N.M. Kozlov).

11. Izuchenie zemnykh prilivov. Sbornik statei No. 3. Otv. red. Yu.D. Bulanzhe (Study of Terrestrial Tides. Collection of Articles No. 3, ed. Yu.D. Bulanzhe).

Those interested in these publications should apply to the Committee.

The Marine Geomorphology Cabinet of the Institute of Oceanology of AN SSSR prepared for press new bathymetric maps of the Pacific Ocean on a scale of 1:5,000,000 (Mercator projection), and 1:10,000,000 and 1:25,000,000 (Urmaev pseudocylindrical projection). The data of marine navigational maps and the results gathered by oceanographic expeditions during the past 100 years, and especially during the period of the IGY, were used in compiling the maps.

A new method of geomorphological interpolation was employed to perform the isobaths. Its essence consists of using the characteristic features of the underwater relief, revealed by echo sounders, and the genetic laws governing the distribution of forms, established by marine geological research. It is proposed to issue the maps in the series of MGK publications.

In accordance with decisions made by international organizations the editorial board of the "Soviet Antarctic Atlas" resolved to change the name of Graham Land to the Antarctic Peninsula. This also resolved disagreement about the name of the great peninsula sometimes referred to as Graham Land and sometimes as Palmer Peninsula. It is simultaneously proposed to introduce the name of Southern Ocean for the waters of the Pacific, Indian, and Atlantic Oceans south of the line of subtropical convergence.

(Minutes (No. 5) of the meeting of the editorial board of the "Soviet Antarctic Atlas," 27 September, 1962)

International Scientific News

At its meeting in Yerevan the Executive Committee of the IAU resolved to admit the Academy of Sciences in Berlin (East German Democratic Republic) to membership.

A committee on scientific cooperation between the U. S. A. and Japan, which will contemplate scientific exchange in the fields of oceanography of the Pacific and hurricane study, among others, was established.

The Executive Committee of the International Association of Geomagnetism and Aeronomy formed permanent consulting groups among the IQSY lecturers on geomagnetism, polar auroras, luminosity of the night sky, and aeronomy. Representatives of the Soviet Geophysical Committee were included in all the groups, as follows: In the geomagnetism group (lecturer V. Laursen), Yu. D. Kalinin and V. A. Troitskaya; in the aeronomy group (lecturer M. Nicole), V. G. Istomin and K. I. Gringauz; in the polar aurora group (lecturer J. Peyton), A. I. Lebedinskii; and in the luminosity of the night sky group (lecturer D. Barbier), V. I. Krasovskii. The groups will carry out their work by correspondence.

During the conference of the WMO held in Washington in March, 1962, its participants were shown a special instrument known as "Vidmet." It is designed to provide operational information about the meteorological environment by means of television. Should a hurricane arise and threaten certain areas; "Vidmet" will make it possible to show its course and development on television.

The question of creating a communications network in the southern hemisphere for exchange of meteorological information, like that already existing in the northern hemisphere, was also discussed at the conference. It might then be possible to combine the two networks into a single system.

(Science News Letter, 7 April, 1962)

A symposium on methods of determining the amounts of oxygen, salts, and phosphorus in solution in seawater, as well as evaluation of the purity of the samples taken (of the oxidizability of the bathometers) took place in March, 1962 in Gelendzhik in accord with the recommendation of the Fifth Conference of Representatives of Eurasian Countries. Representatives of eight oceanographic institutes in the USSR, and of the Marine Institute of the East German Democratic Republic, in Warnemunde, participated in the symposium. The precision of chemical determinations was evaluated, and recommendations for standardization and for improvement of chemical methods were adopted.

At the meeting of MKG in Paris, in March, 1962, an IQSY subcommittee was established to coordinate plans and programs of observations for the period of preparation for the IQSY and the IQSY itself. The directorate of this subcommittee included Professor V. Beinon (president), Professor M. A. Pomerants, G. Rigini, and N. V. Pushkov (vice-presidents). N. V. Pushkov (Doctor of Physical and Mathematical Sciences and President of the Soviet Working Commission of the IQSY) was present at the directorate's next meeting, held in London from 3 to 5 December, 1962.

The report of D. K. Wark, Director of the Physical Meteorology Division of the U. S. Weather Bureau and the meteorologist R. U. Popham at the International Symposium on Meteorological Research Using Rockets and Satellites contained an analysis of the photography of ice distribution in the St. Lawrence River (North America), taken from the "Tiros" satellite. The photographs were transmitted to earth by television and were then compared with aerial photographs of the same region, taken from an airplane on the same day.

On the photographs taken from the satellite, objects with a cross-section of 1.5 km or more are distinguishable. Moreover, various types of ice are distinguishable on them. It is thought that in the future the information obtained from the "Nimbus" satellites planned to be launched will make it possible to make daily maps of the position of the ice.

(Science News Letter, 5 May, 1962)

The First International Symposium on Recent Crustal Movements, held in Leipzig in May, 1962, made a resolution to hold symposia on this subject every three years. The Finnish delegation to the Thirteenth General Assembly of IGGU in Berkeley proposed that the Second International Symposium on Recent Crustal Movements be held in 1965 in Helsinki.

The International Symposium on the Theoretical Interpretation of Emission in the Upper Atmosphere took place in Paris from 25 to 29 June, 1962. It was organized jointly by IAU and IGGU, with Professor J. W. Chamberlain of the Yerkes Observatory (Williams Bay, Wisconsin) as head of the organizing committee.

(Journal of Atmospheric Sciences, March 1962)

A meeting of the Consulting Conference of Countries Participating in the Antarctic Agreement was held in Buenos Aires from 18 to 28 June, 1962. The Soviet Union was represented by A. P. Alekseev (head of delegation), E. I. Tolstikov, and A. P. Movchan. The Conference made a number of recommendations for the further practical implementation of the Antarctic Agreement, and in particular, resolved: (a) to support measures for the IQSY; (b) to improve the exchange of data and publications on the Antarctic through existing World Data Centers; (c) to complete by 1 July, 1963 the collection of observational data on the Antarctic through and including 1961 in the World Data Centers, and thereafter to send out such materials no more than a year after conclusion of the expedition; (d) to conserve animal and plant life in the Antarctic, etc.

The International Association of Meteorology and Physics of the Atmosphere of IGGU and WMO convened a symposium on natural and artificial radioactivity in the atmosphere in Utrecht (Holland), between 8 and 14 August.

(WMO Bulletin, v. XI, No. 3, 1962)

The conference of the Subcommittee on Polar Auroras of the Association of Geomagnetism and Aeronomy of the IGGU took place 3-8 September, 1962, in Edinburgh. S. I. Isaev, Vice-President of the Polar Aurora and Luminosity of the Night Sky Section of MKG and Director of the Polar Geophysical Institute in Murmansk, participated.

The principal item on the agenda was discussion of proposals for an International Atlas of the Polar Auroras, to be published before the beginning of the IQSY. The Atlas would be widely used for stationary observations.

A Soviet delegation participated in the meeting of the International Gravimetric Commission of the International Association of Geodesy of IGGU, held in Paris, 10-15 September, 1962. It consisted of Yu. D. Bulanzhe, Vice-President of the Committee, M. U. Sagitov, Deputy Director of P. K. Shternberg State Astronomical Institute, and K. E. Veselov, Director of the Laboratory of the All-Union Geophysics SRI of the Ministry of Geology and Conservation of Mineral Resources of the USSR.

The agenda included absolute gravity measurements, an international first-order gravimetric network, an international network of gravimeter standardization, measurement of gravity in the sea and from airplanes, use of gravity anomalies to decide fundamental problems of geodesy, measurement of the vertical gradient of the force of gravity, etc. The results of research in different countries were discussed, so as to prepare summary reports to be presented to the International Association of Geodesy at the General Assembly of the IGGU.

The regular conference of the European Seismological Commission of the International Association of Seismology and Physics of the World's Mineral Resources of the IGGU was held 24-30 September, 1962, at Jena (East

German Democratic Republic). The theme of the conference was "The Earth's Crust over European Territory," and the sessions were held in the Geological Institute of the University of Jena.

A scientific expedition comprising 22 men (representatives of Australia, New Zealand, England, India, and the U. S. A.) spent a winter in the Himalayas, in the valley of Mingbo (Nepal), at an altitude of 5720 m above sea level. For the first time at such an altitude, glaciological and meteorological research was carried on over an 8 month period.

A cartographic survey was made of Silver Hat Glacier, lying roughly 20 km from the peak of Chomolungma (Everest). A triangulation survey was made with a Wild theodolite. Four anemometers were placed on an aluminum mast 4 m high. Maximum and minimum temperatures, barometric pressure, humidity, temperature of condensation, wind velocity and direction, cloudiness and precipitation were all recorded. Similar measurements were made at the Green Hat camp (altitude 5300 m), so that a vertical temperature profile could be determined.

The weather was clear from October to December and from the middle of February to the middle of May. The winter lasted a month and a half, and the minimum temperature was -27.2°. The amount of precipitation was negligible, and most of it fell during the monsoon period (June to September).

Twenty-five rods for glaciological measurements were set up. The velocity of movement of Silver Hat Glacier was found to be about 2 cm/day. Six thermistors were inserted in the ice stratum to a depth of 10 m. The ice temperature was found to be minimum on the surface, where it varies with daily variations in the air temperature. With depth the temperature increases, becoming stabilized at about 0° at a depth of about 5 m. It was noted that these temperature characteristics are usually proper to glaciers in the temperate zones (for example, in the Alps), whereas in the polar regions the ice temperature decreases with depth.

Holes were dug in order to study the density, crystal structure and stratigraphy of the snow. Paleoclimatological observations were made in the region of the ice fall, and the direct and reflected solar radiation were measured, using an Apley radiometer for the first time at this altitude.

The organization most interested in the results of this research, which is now being analyzed, is the National Aeronautics and Space Administration of the U. S. A., which intends to use them for the launching of "Tiros" meteorological satellites. The expedition was financed by the United States Air Force, the British Council for Medical Research, the National Geographic Society (U. S. A.), and a publishing company.

The expedition was headed by Sir Edmund Hillary of New Zealand, one of the first party to climb Chomolungma and Head of the British Commonwealth Transantarctic Expedition of 1957-1958.

(National Geographic, October 1962)

Within the Astronomy National Committee of the U. S. A. a subcommittee has been established for the coordination of astronomical research in the countries of the American continent. A number of South American countries will receive new equipment for optical observations from the U. S. A. Several telescopes are being built in Venezuela, a 210-cm reflector is being constructed in Argentina, and a 150-cm reflector in Chile. Particular attention has been devoted to the development of radio astronomy.

The observatory of the University of Chile is carrying out observations of solar radio noise at a frequency of 175 Mc. Argentina, Peru, and Chile are all observing artificial satellites, and in Argentina, at the beginning of the IQSY, the observatory at El-Leoncito, more than 2000 m above sea level, will come into operation. This observatory, which will be equipped with a paired 20-inch refractor; is being built by Columbia and Yale Universities, with funds from the Ford Foundation.

(ICSU Review, v. 4, No. 1, 1962)

The World Meteorological Organization sent four experts to assist in launching the recently founded Institute of Meteorology and Geophysics in Pakistan. They helped to build a telemetric system for atomspheric observations, set up study of the relations between electric fields and evaporation, and delivered a number of lectures.

(WMO Bulletin, v. XI, No. 3, 1962)

Professor G. Jeffreys (Cambridge, England) and Professor F. A. Vening-Meinesz (Utrecht, Holland) shared the Vetlesen award, which carries with it a cash prize of $25,000. It is awarded every two years "for work contributing to a clearer understanding of the earth, its history, and its place in the universe."

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

The following countries reported their participation in the IQSY: England, Australia, Austria, Argentina, Belgium, Bulgaria, Bolivia,

IQSY symbol, ratified by the Rome meeting of IQSY.

Hungary, Venezuela, North Vietnam (Democratic Republic of Vietnam), Ghana, Guatemala, East German Democratic Republic, Greece, Denmark, Israel, India, Indonesia, Iceland, Iran, Ireland, Spain, Italy, Canada, the Congo, Columbia, North Korea (Korean Democratic People's Republic), South Korea, Cuba, Malagasy Republic, Mexico, People's Republic of Mongolia, Nigeria, the Netherlands, New Zealand, Norway, United Arab Republic, Pakistan, Peru, Poland, Portugal, Rhodesia and Nyasaland, Rumania, Senegal, USSR, U.S.A., Finland, France, West Germany (German Federal Republic), Ceylon, Chile, Czechoslovakia, Sweden, Switzerland, Yugoslavia, Republic of South Africa, Ethiopia, Japan.

Abroad

One of the world's biggest radiotelescopes is being built in Canberra (Australia). The National Science Foundation gave Sydney University $150,000 for construction and operation of the telescope, which is named for its designer, Dr. B.I. Mills.

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

An English expedition which undertook glaciological research in southern Greenland studied the glaciers flowing into Tasermiut Inlet (61° N. lat., 41°30' W. long.). Detailed glaciological, meteorological, geological, and botanical research was done on Sermitsiak glacier. The data obtained were compared with the results of measurements performed in 1957 and 1960. A comparison of these results with aerial photographs showed that the glaciers of this region are retreating. Maps of Sermitsiak Glacier, on a scale of 1:10,000 are now being prepared for press.

(Ice, No. 10, July 1962)

B.D. Loncarevic and D.H. Matthews of the Department of Geodesy and Geophysics in the University of Cambridge (England) published in "New Science," 7 June 1962, preliminary results of research which they conducted in the Indian Ocean from H.M.S. "Owen." They report that by echo-sounder they found, on each of three crossings of the Carlsberg ridge, the expected deep "median" valley. By bathymetric, gravimetric, and magnetic observations, they delineated the postulated "Mozambique geosyncline," as a 200-mile-wide off-shore zone, extending from Socotra Island to Madagascar. Granites were discovered in the region of the Seychelles Islands. The samples of mica sent from there to Cambridge have been dated as pre-Cambrian. In the central part of the Archipelago, around the largest islands, "enormous magnetic anomalies" were discovered, leading the authors to the hypothesis that the Seychelles Islands are "much more than a continental fragment." A research voyage of the "Discovery" in this region is planned for 1963.

(ICSU Review, v. 4, No. 3, 1962)

An expedition from Cambridge University (England) in Karakoram worked for a month and a half on Minapin Glacier, in the region of Nagar, northeast of Mt. Rakaposhi (Jammu and Kashmir, India). The movement of the glacier and its ablation were measured, and the characteristics of its moraines and other geomorphological features were studied. The research party was headed by J. Steli, and the head glaciologist was P. Hamble.

(Ice, No. 10, July 1962)

The data obtained by Cha Pa observatory, set up in North Vietnam (φ = 22°21'N. Lat, λ = 103°50'E. long., h = 1578 m above sea level) with the assistance of Poland, for the period of the IGY (1 January, 1958 to 31 January, 1959) included the results of radiosounding using the most advanced Vaisal radiosonde with point recording.

The thermodynamic structure of the troposphere and the lower stratosphere were studied in great detail. Four hundred ninety-one of 715 sondes reached the tropopause, which in this region is located at an altitude of about 100 mb (16 km). In particular, in the upper troposphere (predominantly between the levels of 225 and 150 mb), for the most part in the spring and summer daytime, atmospheric layers with superadiabatic temperature gradients, i. e., layers of great instability, were discovered. This instability was more sharply expressed at Cha Pa than the reduced stability of the layer, observed beneath the tropopause in temperate latitudes. K. Gaman, who studied this phenomenon, assumes that the superadiabatic layers are connected with the regions of great "clear air turbulence" on the background of the comparatively stable atmospheric layer between the levels of 400 and 100 mb.

Comparison of similar phenomena (which are, for example, quite dangerous for airplanes) in the tropical and temperate latitudes will probably help to determine their causes, which are still unclear.

(Acta Geophysica Polonica, v. 10, No. 2, 1962)

The new building of the Central Institute of the Meteorological Service of Israel, located between Tel-Aviv and Jerusalem, was opened in 1962. It contains 120 rooms with a total area of 4200 m^2, housing, in addition to administrative offices, a laboratory for physics of the atmosphere, departments of climatology (equipped with IBM computers), radiosonde calibration, and forecasting, an agrometeorological section, a library, an auditorium with 100 seats, workshops, a printing department, etc. In a neighboring building laboratories and studies are equipped for scientists coming from underdeveloped countries for training in meteorology and climatology of arid zones.

(WMO Bulletin, v. XI, No. 3, 1962)

The Geological Administration of New Zealand has reported that the retreat of glaciers on the Southern Island of New Zealand has been definitely established. Franz-Joseph Glacier, which extends some 14 km, retreated 100 m in the year 1960-1961, and has retreated about 1200 m from 1951 to the time of writing. The glacier is photographed every week. Its retreat is ascribed to the small amount of precipitation that has fallen during these years. Between 1941 and 1946, years of abundant precipitation, some advance of the glacier was noted. Since 1958, however, it has retreated 650 m, and it is thought that several years with considerable precipitation will be necessary to compensate for this retreat. Franz-Joseph Glacier and Fox Glacier, located some 20 km away from it, are descending into a tropical forest. They are the only glaciers outside the polar regions which are descending so close to sea level.

(Science News Letter, 28 July 1962)

The American satellite S-16 ("OSO I") for solar research was put into orbit on 7 March 1962. More than 75 solar bursts had been recorded by the satellite by 22 May. According to a statement by a representative of the NASA, only one of these bursts was accompanied by radiation which may have been dangerous for cosmonauts.

(Aviation Week, v.76, No. 24, 1962; Missiles and Rockets, v. 10, No. 24, 1962)

The meteorological satellite "Tiros V" was launched by a three-stage "Tor-Delta" rocket-carrier from Cape Canaveral*, Florida, on 19 June, 1962. The height of its circular orbit was 555 km, inclination 58°, and period of revolution 97 min. The satellite is primarily intended to detect approaching storms and hurricanes, which are most frequent in August and September.

Because of a breakdown in the radio control system the satellite entered an orbit different from that predicted, with perihelion about 530 km, aphelion about 980 km, inclination of the orbit plane to the plane of the equator 58.1°, and period of revolution 100.5 min.

According to a NASA official, this will not interfere with performances of the planned experiments.

(Missiles and Rockets, v. 10, No. 26, 1962; Interavia Air Letter, No. 5016, 5020, 1962)

The Soviet Geophysical Committee received telegrams from the U. S. A. Committee on Geophysical Research with the following contents.

1. The meteorological satellite 1962-$\alpha\psi$ (Tiros VI") was launched on 18 September, 1962 at 8.53:09 Greenwich mean time from Cape Canaveral, Florida. Preliminary orbital data: inclination 58.3°, apogee 711 km, perigee 684 km, period of revolution, 98.7 min.

Upon command the satellite transmits accumulated or directly obtained photographic data on the cloud cover distribution by means of two 235-Mc 2-watt transmitters. Two tracking beacons operate continuously at frequencies of 136.23 and 136.92 Mc with a power of 50 milliwatt. The satellite went into orbit on 18 September at 9.04:42 at a point located at approximately 46.55° N. lat. and 57.3°W. long.

The satellite is cylindrical in shape, 42" in diameter and 22" high, and its surface is covered with solar batteries to recharge its chemical batteries. It carries one wide-angle and one medium-angle television

* [Now called Cape Kennedy.]

camera, each of which consists of a half-inch vidicon tube, a stop valve in the plane of the focus, and a magnetic guiding coil which receives commands for slow alteration in the orientation of the satellite axis in space from stations on the earth.

Since the launching date was changed, in order to include the hurricane and typhoon period and to obtain supplementary information about distribution of the cloud cover at this period, and for future manned flight, the satellite was not equipped with instrumentation for experiment with infrared rays. The tracking beacons upon command communicate data on the functioning of the satellite's instruments, its altitude, and the state of the medium.

The satellite weighs 281 lb. The third stage of the rocket, which is 60" long and 18" in diameter, is also in orbit.

2. An experimental active radio relaying communications satellite 1962-$\alpha\epsilon$ ("Telstar I") was launched from Cape Canaveral on 10 July, 1962 at 8.35 Greenwich mean time. According to preliminary data, the orbit inclination is 44.793°, apogee 5637 km, perigee 953.5 km, and period 157.81 min. The satellite receives radio signals at a frequency of about 6390 Mc, amplifies them 2 billion times, and transmits them to earth at a frequency of approximately 4170 Mc at a constant power level of 2.25 watt, by means of a traveling wave tube.

Experiments on the measurement of proton and electron concentration in the inner Van Allen belt, and of their energies, as well as of the effect of radiation on semiconductors, were performed on the satellite. The point tracking beacon (with a traveling wave tube) operates at a frequency of 4080 Mc and a power level of 25 milliwatt. A telemetric transmitter at 136 Mc and 350 milliwatt assures its continuous operation.

The satellite entered its orbit on 10 July at approximately 8.51 Greenwich time, at a point with coordinates 9° N. lat. and 47°W. long. The satellite is almost spherical in shape, 863.6 mm in diameter and 939.9 mm in height, and weighs 77.112 kg. Its surface has 72 facets upon which 3600 reflecting mirrors to facilitate visual observation are distributed, as well as solar elements for recharging of the nickel-cadmium batteries (initial output power 15 watt). "Telstar" carries instrumentation for measurement of the parameters of the surrounding medium, temperature of the satellite envelope, pressure inside the satellite, etc., and for monitoring path and instrument characteristics.

The initial experiments performed within the boundaries of the country must include radio relaying of telephone conversations recorded on magnetic tape, television images of current events, and express information. The subsequent transatlantic experiments, performed with the collaboration of Great Britain, France, Italy, and West Germany, included a 12-minute transmission of the latest news from the U. S. A., telephone conversations, transmission of photoimages and other information. The third stage of the rocket-carrier, which is 1524 mm long and 457 mm in diameter, is also in orbit.

3. The space sonde 1962-$\alpha\rho$ ("Mariner II") was launched from Cape Canaveral on 27 August, 1962, at 6.53 Greenwich mean time. On the same day at 10.53 it was at a point with coordinates 8°S. lat. and 65°E. long., 74,000 km above the surface of the earth. The sonde was to fly past Venus, study the planet, and obtain data about phenomena in interplanetary space. It transmits the data at a frequency of 960.05 Mc and at 3 watts of power.

The sonde weighs 202.76 kg and has the form of a hexagonal base 1,524 m in diameter, screwed on to a cylinder 3,026 m high. Together with its uncovered solar panels and high-amplification antenna, the sonde has a span of 5,029 m and a height of 3,632 m.

The scientific tasks to be performed during flight past Venus include infrared and microwave research, determination of the intensity and direction of the planet's magnetic field, and of the distribution and intensity of charged particles, concentration of cosmic dust and its kinetic energy, flow of solar plasma and the concentration and energy of particles in it. Electromagnetic radiation on waves of 13.5 and 19 mm, and within the ranges of 8 to 9 and 10 to 10.8 micron is also to be measured.

The second stage of the rocket-carrier, 6,706 m in length and 1,829 m in diameter, moves on a trajectory of its own which differs from that of the sonde and is so chosen as to avoid collision with Venus.

4. The 1962-$\beta\alpha$ satellite ("Alouette") for sounding of the upper ionosphere was launched from Point Arguello (California, 34°45' N. lat., 120°37'W. long.) at 06 hr. 05 min. Greenwich Mean Time on 29 September, 1962. Initial data gave the orbit inclination as 80°, apogee 1045 km, perigee 997 km, and period 105 min. The satellite and the planned experiments were developed in Canada, but the launching was done by the U. S. A.

The scientific tasks to be accomplished included vertical sounding of the ionosphere between the satellite and the maximum of the F2 layer, measurement of radio noise arising in outer space and in the ionosphere, and observation of cosmic rays. Upon command from the earth telemetric data are transmitted at a frequency of 136,080 Mc (power 2.0 watt) and at freq frequency 136,590 Mc (power 0.25 watt). An unmodulated signal from the radio beacon is continuously transmitted at a frequency of 136,980 Mc and power level of 50 milliwatt.

The satellite is an oblate spheroid 145 kg in weight, 105 cm in diameter, and 85 cm in height. When fully extended the span of one antenna dipole is 45.72 m, and of the other, 22.86 m. Battery recharging is by solar elements. The goal of the experiments is to study daily changes in the ionosphere below the satellite at all latitudes, to determine electron density at the altitude of the satellite by measuring cosmic noise, to determine the audible frequencies in the radio spectrum of very low-frequency signals, and to study the particles of primary cosmic rays. The envelope of the second stage of the rocket, which is 671 cm long and 152 cm in diameter, is also in orbit.

In the U. S. A. Lenhard published the results of a series of wind observations in the stratosphere above Florida in May 1961. Spheres of half-mil mylar 1 m in diameter, full of gas with built-in aluminized quarter-mil corner reflectors were thrown from geophysical rockets at an altitude of about 700 km. The density of the air and daily wind variation between the altitudes of 70 and 30 km were determined by radar observation of the velocity of fall and side drift of the spheres.

Lenhard's data show that a well-defined tidal motion in the wind is propagated downward to a level of about 43 km and that the corresponding wind velocity components reach 4.4 m/sec from west to east and 5.5 m/sec from north to south at an altitude of 64 km, and 3.9 and 4.2 m/sec, respectively, at an altitude of 43 km. Below 35 km they evidently damp out, since in the lower stratosphere no tidal phenomena of any sort can be expected as part of the wind and weather cycle.

(Journal of the Geophysical Research, v. 68, No. 1, 1963)

J. P. Chrissman, Director of the National Meteorological Center of the U. S. A. at Suitland, Maryland, reported to the Washington meeting of the American Meteorological Society that a mathematical model of the earth's atmosphere, which makes it possible to use electronic computers for weather forecasting, has been developed. The model divides the atmosphere into three layers, which permits the computer to take into account the effects resulting from air friction against the surface of the earth. The model considers air temperature as well as pressure. The use of this "three-layered barocline" model is expected to bring about a considerable improvement in forecasting methods.

(Science News Letter, 12 May 1962)

At the Woods Hole Oceanographic Institute in Massachusetts, directed by A. J. Faller, experiments in reproducing the process of cloud formation are under way. Spiral cloud belts like those typical of tropical hurricanes have been obtained on a special rotating pan-like instrument. Introduction of a special dye made movements of the medium visually observable. The artificial spiral belts of clouds, like natural ones, sagged counterclockwise toward the center of the hurricane and flowed together, forming a "wall" around it. The spiral formations were particularly distinct when the center of the hurricane was immobile.

(Science News Letter, 12 May 1962)

On 25 April, 1962, when the test firing of the "Saturn S-1" rocket from Cape Canaveral took place, an incidental experiment called "High Water" was conducted. Its object was to determine the composition of noctilucent clouds. Instead of second and third stages the rocket carried 95 tons of water as ballast. This water, thrown out of the rocket at an altitude of 100 km, immediately changed into ice crystals and diffused over some 12-15 km with a velocity of about 3.5 km/sec. After 10-12 sec the cloud disappeared. This experiment is thought to support the theory of the dust composition of noctilucent clouds, since at this altitude water vapor rapidly diffuses.

(Science News Letter, 12 May 1962; Discovery, June 1962)

At the American Geophysical Union Conference in Washington J. Fry suggested seeking the segregation of manganese concretions on the ocean floor by an acoustic method. The reflections of sound waves, which originate from an instrument on board a ship, from such segregations enter at an uncommon angle. Experiments using the new method were set for 40 stations located in different parts of the Pacific Ocean.

(Science News Letter, 12 May 1962)

The General Electric Company has developed a miniature ionization chamber, 12.7 mm long and 2.5 mm wide, for installation on satellites, where it can be used to measure cosmic radiation.

(Missiles and Rockets, v. 11, No. 1, 1962)

A. Ben-Menachem and M. N. Toksots of the Caltech Seismologic Laboratory have developed a method for analysis of seismologic observational data using electronic computers. Data on the surface waves resulting from great earthquakes permit determination of the direction, velocity, and extent of the displacement of the earth's crust. In particular, it proved possible to establish the displacement of the earth's crust resulting from the Chilean earthquake of 1960 at about 1000 km, mostly beneath the Pacific Ocean. Ben-Menachem and Toksots estimate the length of the displacement caused by the Mongolian earthquake of 1957 to be about 550 km. Their further research will include the study of the depth of such displacements and analysis of abyssal waves.

(Science News Letter, 2 June 1962)

Near Palestine, Texas, a new geophysical station has been established for the launching of spherical sondes equipped with instrumentation for study of the high layers of the atmosphere and primary cosmic radiation. Optical telescopes will also be installed on the sondes. The station was set up by the National Center for Atmospheric Research, Boulder, Colorado.

(Science News Letter, 9 June 1962)

A new telescope for solar study has been put into operation at Kitt Peak Observatory, 65 km south-west of Tuscon, Arizona. The telescope, which has a focal length of 300 ft, will give photographs of the sun 34" in diameter, and will therefore facilitate very detailed solar research. The new instrument has been named for the late Professor R. MacMatt of Michigan University, who first had the idea of building it.

(Science News Letter, 9 June, 1962)

The Smithsonian Astrophysical Observatory of Cambridge, Massachusetts, has established in seven midwestern states a special network of sixteen stations for observation of meteors. The stations are located in the following small towns, where electrical illumination will not interfere with the observations: Havana, Illinois; Milan and Vienna, Missouri; Winton and Maple River (Iowa); Liberty, Alma, Neligh, and Mallen (Nebraska); Farlinville, Hessel, and Calvesta (Kansas); Ward and Lower Brule, South Dakota; Cedardale and Hominy (Oklahoma). Four cameras have been set up at each of these stations, making a total of 64, one for each country of the world [sic]. These cameras will automatically photograph the sky on "3-X-Panfilm" from sunset to sunrise, and will register all objects, beginning with the eighth stellar magnitude.

A member of the local staff will visit each station once every 24 hours, and a scientist from the network center in Lincoln, Nebraska, twice a month. The film will be developed on the spot, then sent to Cambridge.

When a very bright meteor which seems likely to fall upon the earth is recorded, research is begun to determine its composition and radioactivity as soon as possible. The network is directed by R. MacCrosky.

(Science News Letter, 16 June 1962)

R. H. Dickey of Princeton University has proposed a new gravimeter using a pendulum to measure the force of gravity within a wide range. The special design greatly reduces the effect of oscillations from distant earthquakes, microseism, and other interference, which usually distort the readings of gravimeter with low oscillation frequency. The inventor received Patent No. 3036465.

(Science News Letter, 16 June 1962)

V. K. Zvorykin and J. Shicklan of Princeton have developed a new method for measurement of an electric field in the atmosphere, and have taken out Patent No. 3038154. When the location of the electric field in clouds is determined, information about the movement of air masses can be obtained.

J. Bigelow and others have received Patent No. 3037421 for an arrangement for measurement of the number of condensation nuclei in small air samples by observation of their scattered light.

(Science News Letter, 23 June 1962)

American glaciologists have field tested a new type of electrothermo-drill at Camp Century Station (220 km north of Thule, Greenland). The drill is equipped with an electrically heated collar 2.5 cm thick and 15 cm in diameter, which promotes melting, and advances at a rate of up to 15 cm/min. As it goes deeper the ice cylinder is trapped in the core. It is thought that this drill will make it possible to reach ice layers deposited at the beginning of the Pleistocene Age, i. e., about 1 million years ago. It is planned to carry out a C_{14} analysis of the air trapped by the ice. The work is directed by Colonel U. L. Nangesser, Director of the Army Laboratory for Research and Construction in the Polar Regions (Hanover, New Hampshire).

(Polar Times, June 1962)

U. I. Davis and D. B. Crinsly, geologists from the U. S. A. Geological Survey, together with the Danish geologist A. Veidik, have been doing research in the extreme north of Greenland, in the region of Independence and Sand Fjords and Frederick Hyde Fjord.

They believe they have established that during the age of the Wisconsin glaciation in this region it was only in certain valleys that the glaciers descended to the sea, leaving the greater part of the coast bare. They conjecture this to be the result of the extremely low precipitation in the region, which in turn is to be explained by the great distance of the region from open masses of water. In the opinion of the expedition members, the last extreme retreat of a glacier in this area occurred about 9000 years ago. Ice melting 8550 years ago made the sea level about 80 m higher than it is at present. About 3700 years ago the valley glaciers advanced to some extent, after which they retreated to their present position.

On 9 May, MIT scientists performed an experiment during which the region of the lunar surface about the crater Albategnius was illuminated by a powerful beam emitted by a laser. In the future American scientists hope to use this method for space communications.

(Science et vie, Juillet, 1962)

On 7 June, 1962, as part of the American-Pakistani program of upper atmospheric research, a "Nika-Cajon" American two-stage research rocket was launched from the Sonmiani Proving Ground (56 km from Karachi). At an altitude of about 130 km the rocket, which received the name "Rechbar I", was used to form a sodium cloud, containing 36 kg of sodium.

(Flight, v. 81, No. 2781, 1962)

On 7 August, 1962, as part of the joint American and Swedish program of research on cloud illumination, the first "Nike-Cajon" rocket was launched from the Kronogaard Proving Ground in the region of Mt. Vidsel (northern Sweden). The rocket reached an altitude of 120 km, and dropped a container of instruments by parachute.

On 11 August, 1962, at the same location, the second American two-stage "Nike-Cajon" research rocket was successfully launched to an altitude of 38.6 km. Another such rocket was launched on 18 August, 1962 from the Andoya (Andoy I. Norway) Proving Ground, as part of a joint Norwegian and Danish program of research on the nature of the polar auroras in Norway. Until the moment of release of the container with instruments the rocket had attained an altitude of 106 km.

(Interavia Air Letter, Nos. 5050, 5060, 1962)

The American nuclear explosion of 9 July, 1962 (Operation "Starfish") gave rise to an artificial radiation belt. The explosion took place in the ionosphere several hundred kilometers above Johnston Island (17°N. lat., 191°7' E. long.). Abbreviated information abouts its effect was published in the "IG Bulletin," No. 64. The electromagnetic effect was observed in the Antarctic, at Scott Station (New Zealand) and Hallet Station (U. S. A. - New Zealand). Ionospheric perturbation, which reached a maximum 2.5 hours after the explosion, was noted in the D layer, but ionospheric whistlers were not noted. For several hours after the explosion earth current recordings showed an insignificant variation.

On 3 August, 1962 at Eglin Air Force Base an "Exos" rocket was used to launch a steel sounding-balloon to an altitude of 72 km for collection of data on the temperature and charged particle density in the ionosphere.

An English "Skylark" rocket for ionospheric research was successfully launched from Woomera Proving Ground, in Australia, on 15 August, 1962. The rocket, which reached an altitude of 125 km, contained apparatus for research on radio wave transmission, study of the distribution of atomic hydrogen in the atmosphere, and measurement of the density of positively charged ions in the ionosphere.

(Flight, v. 89, No. 2789, 1962; Missiles and Rockets, v. 11, No. 9, 1962)

R. von Eschelman and O. K. Harriot of Stanford University Radiation Laboratory have proposed a new application of radar to research on the sun, moon, and planets of the solar system, as well as to radio wave propagation in space. Their proposal aims at avoiding the losses of information caused by the diffusion in space of radio waves sent from the earth and reflected by the celestial body being studied.

The scientists proposed making radar sounding coincide with the launching of a space rocket toward the planet. When this happens the radio signal reflected from the planet will reach the receiver on the rocket before it can be diffused in space. Information about the surface of the planet can then be fully and reliably transmitted to earth. There will, of course, be sufficient powerful means of transmission in addition to the low-power receivers installed on satellites. If the spaceship is obscured by the body of the planet, it will be possible to measure the density of its atmosphere while recording radio frequencies.

The new method can also find wide application in study of the solar corona and of the interplanetary gases flowing away from the sun. Its use was also proposed for the launching of the "Mariner II" rocket to Venus.

(Science News Letter, 8 September 1962)

J. L. Greenstein of Palomar Observatory has reported certain peculiarities which he noted while observing the comet Humason (1961-e). He established an interaction between the comet and the "solar wind," which is noteworthy since such interactions have previously been observed only when comets passed comparatively close to the sun, while Humason, between the orbits of Mars and Jupiter, was approximately 385 million miles distant from the sun.

Photographs show that because of solar radiation the nitrogen and carbon monoxide constituents of the comet underwent ionization. Humason, a comet of the eighth magnitude, can be seen in the southern hemisphere and has a period of revolution of 2900 years.

(Science News Letter, 8 September 1962)

L. M. Slifkin of the University of North Carolina has developed a new method for the discovery of cosmic rays. It consists in using as a detector a large crystal of silver chloride, which grows dark under the action of cosmic rays. Slifkin's method makes it possible to detect comparatively rarely found particles of heavy elements, and will be used in research on board American artificial earth satellites.

(Science News Letter, 8 September 1962)

J. L. Reid, Jr., has reported that researchers of the Scripps Oceanographic Institute (La Jòlla, California) have detected diurnal fluctuations in Californian currents. He regards these variations as being connected with the influence of the moon on water masses. Some are of the opinion that fluctuations in the open sea occur only in those latitudes where the movement of oceanic water coincides with the tides. The results of this research are presented in the magazine "Deep-Sea Research."

(Science News Letter, 8 September 1962)

F. Press, Director of the Caltech Seismic Laboratory, has reported on the construction, by his colleague, U. Miller, of a new apparatus which is a combination of computer and seismograph. A standard seismometer converts vibrations of the earth's crust into electrical impulses. The next unit of the apparatus fixes the pulses and conveys them to the "tongue" of the electric computer. The material is then transferred on to half-inch magnetic tape which can be fed directly into the computer. This new apparatus has great "flexibility," which permits its use for recording of the whole range of seismic phenomena. Press is of the opinion that it greatly increases the possibilities of collecting and analyzing information about natural and artificial tremors of the earth's crust, and also increases the accuracy and dynamic horizon of the research. It will be possible to select from the general "seismic background" phenomena of particular interest to the researcher. One day will be sufficient for the analysis of the data on numerous phenomena, gathered over a week, and a sort of "earthquake library" is being created. The scientists of Tasmania, India, and several other countries have expressed interest in the contents of the "library."

(Science News Letter, 27 October 1962)

The General Dynamics corporation has revealed the construction of a new electronic device for measurement of sea currents. Its sensitivity makes it possible to determine the movement of water masses of velocity above 1 mile per 3.5 days to 20 decimal places. The new instrument shows flow direction relative to the magnetic north with an accuracy of 2°. It is about 20 cm in diameter and 25 cm in length.

(Science News Letter, 27 October 1962)

Meisinger awards for work on radar meteorology and cloud physics were awarded in 1962 to L. J. Battan of the Institute of Atmosphere Physics of the University of Arizona.

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

Professor M. Young of the Lamont Geological Observatory of Columbia University has been awarded a Collum medal for work in oceanography by the American Geographical Society.

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

F. F. Clapp, Director of the Research Section of the Long-Range Forecasting Division of the U. S. Weather Bureau, has made a great contribution to meteorology in the area of long-range forecasting. He has been awarded the silver medal of the Ministry of Trade of the U. S. A. "for outstanding service." H. K. Cratcher of the National Center of Meteorological Archives of the U. S. A., in Ashville, North Carolina, has been awarded the same medal for attainments in meteorology and climatology of the upper atmosphere.

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

Professor Sidney Chapman, former president of the Special (International) IGY Committee, has been awarded the Bowie Medal, annually given by the American Geophysical Union, for outstanding scientific service. The medal was founded in 1939. Among those who have received it are J. Fleming, J. Bjorkness, F. Vening-Meines, W. Lambert H. Sverdrup, G. Jeffreys, B. Gutenberg, M. Young, and other outstanding scientists.

(Transactions of the American Geophysical Union, v. 43, No. 2, 1962)

The results of acoustic observations of temperature and winds in the upper atmosphere (up to an altitude of 50 km), conducted from November, 1957 to July, 1959 (IGY — Participation française. Ser. II, Fasc. 4. Météorologie — sondages acoustiques de la haute atmosphère. Paris, CRNS, 1962) have been published in France.

The explosions took place at Le Rucharre on the Loire. The monitoring stations were located at a distance of 200-250 km. Three hundred seventeen paired explosions took place, and the data of 216 explosions were analyzed. A microphone with heated filament and transistor amplifier was used to detect sound waves, and the signals were recorded on paper. The speed with which the tape unwound was 1 to 10 cm/sec. The receiving apparatus showed maximum sensitivity at a frequency of about 8 cps.

Up to five microphones were set up at each point. Winds above 7 to 8 m/sec at ground level at the observation point were sufficient to create noise impeding the clear recording of signals. Simpler synoptic situations were selected for observation. The accuracy of signal timing was as high as 0.01 to 0.001 sec. Analysis of data and calculation of temperature and of both wind components were carried out by successive approximations using radio sonde data on an IBM-704 computer. The accuracy of temperature determination is estimated at 2 to 3°, that of the wind, 2 to 3 m/sec.

The conventional temperature increase above 30 km to the ceiling of sonde observation was found. The discontinuity (beginning of the mesopause) is best defined in winter. The daily temperature variation, apparently sometimes exceeding 10°, can be noted both in winter and in summer. A sharp afternoon drop in temperature was also noted. The maximum zone was often not reached by sounding. In the summer low winds were observed in the 20 to 35 km layer, and above it, low to moderate easterly winds. In the winter westerly winds increased in force with altitude up to the sounding ceiling. These circulation characteristics proved to be less regular than was previously supposed.

Tables and graphs of the distribution of elements by altitude, etc., are attached. It was noted that acoustic sounding is simple and has a number of advantages over rocket sounding, at least up to 50 km. The analogous observations of Professor Ivo Rokar in the Sahara in 1961, when the signals received after refraction on the border of the D layer at altitudes of 80 to 100 km could be recorded at distances of up to 400 km.

The University of Santiago (Chile) has built a new climatological station in the observatory for cosmic ray study, located in the Andes at an altitude of 4300 m. Cloud research has been begun at the Chilean university of Del Norte, in Antofagasta. In Ecuador 18 new meteorological stations have been built, of which eight transmit the materials of their observations directly to the Meteorological Center located in Quito. A meteorology and hydrology training center is being built with the assistance of WMO in Lima (Peru).

(WMO Bulletin, v. XI, No. 3, 1962)

Repeat determinations of the state of the glaciers in the Swiss Alps have been performed under the direction of Professor A. Reno. It turned out that during the year which ended in September, 1960, 56 glaciers in this region showed a tendency to retreat, and 7 advanced. Among the latter is Allalinhorn Glacier, which recommenced an advance interrupted the previous year. Since it was shown that small glaciers react more pronouncedly than large to short-term climatic variations, detailed studies of the balance of the small glacier Plan-Neve in the canton of Valais are now in progress.

(Ice, No. 10, July 1962)

The ship "Tala Dan" brought fresh winter personnel to Wilkes, the Australian antarctic station, and did some research in coastal waters. In particular, the tongues of Mertz and Ninnis glaciers were studied. According to D. Mawson, who visited this region in 1911, they have jutted out a further 90 km into the sea. Photography from a helicopter, and the work of the shore-based party, made it possible to establish that a considerable part of the tongue of Mertz glacier consists of shelf ice and an iceberg more than 60 km in cross-section, seated on the base. The dimensions of Ninnis Glacier also turned out to be considerably smaller. The largest object in the region, Mt. Horn Bluff, turned out to be an island.

From on board the "Tala Dan" an incidental survey of about 250 km of the Sabrina Coast of Wilkes Land, an aerial radar survey, and determination of the astronomical position were made. The ocean depth was measured over a distance of several hundred miles and the height of the continent as far as 130 km inland was determined from an airplane. At the extreme southern point of the region the surface of the glacier is about 2000 m above sea level. An automatic meteorological station, established at the beginning of 1961 on Cheek Island (Wilkes Land), continued to function for more than five months.

(Antarctic, March 1962)

At the end of 1961 two groups of Australian polar explorers completed research trips from Mawson station inland. They performed geological research in the region of the Prince Charles Mountains, 700 km south of Mawson, at altitudes up to 3000 m above sea level, as well as glaciological and meteorological observations. An incidental feature of the trip was ascent of the region's highest peak, Mt. Menzies (about 3700 m).

A group of six Autralian glaciologists made a trip from Wilkes Station, and proceeded about 300 km inland. Seismic sounding performed en route showed considerable subsidence of the subglacial surface at several points. In some points the rocks are 300 to 500 m, and in one place, approximately 3000 m below sea level. Making use of the rods set up the previous year, the group measured the ice accumulation every 1.5 km. The amount of the accumulation on the ice plateau considerably exceeded expectation.

(Antarctic, March 1962)

The Australian tractor-sledge train reached Vostok station (at the south geomagnetic pole), which was shut up in January 1962. The train left Wilkes supplementary station on 17 September and arrived at Vostok on 18 November, 1962. The group of six people, including one American, was headed by the New Zealander R. Thomson. Two tractors and two "Weasel" amphibious vehicles were used as transportation. Assistance was given by an American "Globemaster" plane, which dropped the necessary fuel. En route meteorological and geomagnetic observations were made, and the thickness of the ice cover was measured. According to those participating in the traverse the maximum ice thickness found was about 4900 m. On 25 November the group began its return journey.

The English R/V "Shackleton" made a magnetic survey in the southern polar regions, including Roberts, Nelson, King George, and Elephant Islands (Southern Shetlands). Gravimetric observations were also made on Gibbs Island.

(Antarctic, March 1962)

In 1962 seven principal and three auxiliary English stations, whose total wintering staff comprised 89 men, were functioning in the Antarctic. On the Argentine Islands and Halley Bay stations a wide range of geophysical research, including study of the polar auroras, meteorological observations, and study of sea tides, was performed. Port Lockroy station was closed at the beginning of the year, and ionospheric observations and the study of atmospheric whistlers were transferred to the Argentine Islands station.

The magnetic survey of the northern part of Trinity Island was extended southward, and now covers the entire region northward from 63°51' S. lat. The marine magnetic survey was made in Bransfield Strait and to the northwest of the Southern Shetland Islands. The gravimetric measurements, including repeats at some points visited in the 1959-1960 and 1960-1961 seasons, cover a considerable part of the Antarctic peninsula southward from Fossil-Bluff (71°21' S. lat.), as well as individual points on the eastern coast. Some paleomagnetic research was also done.

A triangulation survey of the eastern coast of the Antarctic peninsula, taking in Drygalski, Green, and Crane Glaciers, was organized, southward to approximately 65° S. lat.

Triangulation was begun on Adelaide Island, in whose northern part preparation has been made for a tellurometric survey to be extended to Stevenson Nunatak (72°11' S. lat.). Tellurometric profiles were traversed on Roberts, Nelson, Greenwich, and King George Islands, and glaciological study of the ice cap was done on the Argentine Islands. Observations of sea ice are going on at all the English stations.

(Antarctic, September, 1962)

English polar researchers from Hope Bay station made a triangulation survey of the Nordenskjold Coast, the region of the Seal Nunataks, and of part of Oskar II Coast, including geological examination in the region of Larsen Island and geophysical research in the area north of Prince Gustav Bay. A survey was also made of the glacier on Oskar II Coast. A new building was built to house the seismic station on the Argentine Islands, and new equipment for ionospheric research was installed in it. At Halley Bay station the mean temperature in September was -30°, and in October, -16°. A group from this station performed glaciological research on Dawson-Lambton Glacier.

(Antarctic, March 1962]

In November 1961 the precise location of Ellsworth Station, on the Argentine Islands, was freshly determined, and its coordinates were found to be 77°39.3' S. lat., 41°1.8' W. long. According to the previous measurements, made in 1957, these coordinates were 77°42.6' S. lat., 41°0.08' W. long., which shows that the glacier on whose surface the station is located is moving northward with a speed of about 1.5 km per year.

(Antarctic, March 1962)

Several geographical objects in the Antarctic have received names. Among them are Leigh Hunt Glacier (85°05' S. lat., 173°50' E. long.), named in honor of the founder of the New Zealand Antarctic Society; Ford Peak (84°55' S. lat., 173°40' E. long), in honor of a member of Scott's first expedition (1902-1904); Hare Peak (84°49' S. lat., 173°50' E. long.), in honor of a polar explorer who wintered in the Antarctic in 1902; Evans Glacier (83°47' S. lat., 170° E. long.), in honor of a participant of Scott's last expedition who was lost in this region; Wild Ice Fall (84°50' S. lat., 160°E. long.) and Worsely Ice Fall (82°50' S. lat., 156°30' E. long.), in honor of members of Shackleton's expedition.

A group of nunataks located in the region of 85°34' S. lat., 177°30' E. long., were named the Aurora Nunataks, after the ship which brought part of Shackleton's expedition to the Antarctic in 1915. A number of nunataks of this group have been named for members of the Aurora's crew who wintered and drifted with the ship, including Larkman, Moger, Donelly, Ninnis, and Stenhouse Nunataks.

(Antarctic, September 1962)

At the beginning of 1962 the New Zealand Antarctic Expedition concluded its two months of field work in the little studied region of the upper heights of Beardmore Glacier. Two field parties performed cartographic, topographic, geological, and gravimetric work, using an airplane and dog teams for transportation. The regions of the Miller Range (82°35' S. lat., 158° E. long.), Sanford Cliffs (83°50' S. lat., 159°30' E. long.), Bowden Névé (83°20' S. lat., 165°40' E. long.), Low Glacier and the western part of Queen Alexandra Range (83°53' S. lat., 164°10' E. long.) were studied. The most southerly point reached by the expedition workers had coordinates 84°50' S. lat., 162°30' E. long.

Altogether an area of about 28,000 m^2 was covered, and 18 gravimetric stations were performed. Near the Miller Range outcroppings of metamorphic rocks and granites were found. In the region of the Queen Alexandra and Queen Elizabeth Ranges biconic sandstone and fresh continental sedimentary rock containing coal measures were studied. Traces of Gondwana glaciation were found near the basement of the biconic sandstones.

(Antarctic, March 1962)

A group of scientists from the University of Wisconsin, after returning from the Antarctic, reported on their measurements of ice thickness at Amundsen-Scott Station (South Pole). Seismic measurements showed that the ice thickness in that region is about 2600 m. The bed of the glacier is about 180 m below sea level.

(Science News Letter, 9 June 1962)

During the Antarctic summer of 1961-1962 six groups of scientists from the University of Wisconsin performed various geophysical and geological studies in the Antarctic.

Between December 1961 and February 1962 a group of seven American researchers headed by J. Berendt of the University of Wisconsin made a traverse of 1775 km through the unexplored region of Ellsworth Land. The route passed eastward along the Eights Coast to 74° S. lat., 80.5° W. long., then south-eastward to Sky High Station (75°14' S. lat., 77°10' W. long.), east-north-east to the base of the Antarctic peninsula (Graham Land), northward to 73°31' S. lat., south-eastward to 74° S. lat., 66°35' W. long., then south-westward and westward again to Sky High.

En route the altitudes of points above sea level, thickness of the ice cover, snow accumulation, and character of the snow surface were determined, gravimetric and geomagnetic measurements were made, and the mean annual temperatures, character of the rock underlying the glacier, and location of rock outcroppings were found. Gravimetric, magnetometric, and seismic methods were used to determine the ice thickness and the character of the subglacial topography.

The results of these investigations favor the hypothesis that the subglacial channel under a considerable part of western Antarctica may unite the Ross and Weddell Seas. The rock surface, as measurements showed, lies below sea level in an easterly direction at least as far as 71° W. long. The channel stretches eastward from the Ross Sea beneath a great part of Marie Byrd Land and under Ellsworth Land. The extreme eastern point reached by the channel is still unknown, but it is thought improbable that it extends to the Filchner Ice Shelf and the Weddell Sea, dividing Antarctica into two continents.

The traverse of Berendt's group, however, confirmed that the channel does not end at the Bellingshausen Sea, nor does it extend into the Antarctic Peninsula. This means that the channel must either terminate near 71° W. long., or continue to the Filchner Ice Shelf, which thus becomes more probable.

The group making the traverse discovered several previously unknown mountain ranges, including one occupying the region between 75° and 75°30' S. lat. and between 71° to 73° W. long. It was named Mt. Teal, in honor of Edward Teal, a geophysicist from the University of Minnesota, who was seriously injured in the airplane accident at Wilkes Station. It was also established that George Bryan and Robert English Coasts lie farther south than maps indicated, that the base of the Antarctic Peninsula is much narrower than was previously supposed, and that the Lowell Thomas, Sweeney, and Latady Mountains are farther north than was thought.

Another party of nine men, headed by glaciologist M. Giovinetto, began detailed investigation of the Roosevelt Island ice cap. A network of 35 points for glaciological observations was constructed, and seismic, gravimetric, geomagnetic, and meteorological measurements were made.

At the South Pole station seismic studies were made by the method of reflected and refracted waves, and gravimetric measurements were made to determine the ice thickness, velocity of propagation of seismic waves in ice and in the underlying surface, and to study the propagation of acoustic energy in ice at very low temperatures.

Precise determination of the difference in gravimetric parameters between McMurdo, Byrd, and Amundsen-Scott stations was continued, with the object of clarifying the effect of moving stations. Some new gravimetric positions were established in the ice-free region of McMurdo Bay.

In the northern part of the Antarctic Peninsula American geologists worked together with members of the Chilean expedition. They studied sedimentary rocks and performed tectonic investigations near O'Higgins station. Near all of the Chilean antarctic stations, which are "hooked in" to the world gravimetric network, a gravimetric survey was made.

(Antarctic, March 1962; Ice, No. 10, July, 1962)

The North American Arctic Institute organized a scientific expedition to Devon Island, in the Canadian Arctic Archipelago. Oceanographic, glaciological, and meteorological research was done in the almost inaccessible region of Mt. Skarbo (north-eastern extremity of Devon Island). The expedition comprised eleven men and was headed by S. Apollonio.

(Polar Times, June 1962)

From mid-October 1961 to mid-March 1962 a glaciological expedition sent to the Ross Ice Shelf (Antarctica) by the Laboratory of Glaciological Geology and Polar Research of Michigan University, and headed by C. W. M. Swithinbank, continued measurements of the velocity with which the principal glaciers are descending to the western part of the Ross Ice Shelf. Some of the research was done in collaboration with the geophysics group of the University of Minnesota.

A gravimetric survey using a Worden gravimeter was made on Byrd and Nimrod Glaciers and the speed of the ice movement was determined by rods between Mt. Littleton and Mt. Wilson. The group made a traverse of 280 km to Beardmore Station, then another 43 km to the mouth of Beardmore Glacier, performing glaciological and gravimetric measurements en route. Altogether fourteen gravimetric stations were made between Mt. Hope and Aerdrup Peak.

The French Antarctic Expedition made a traverse of 35 km into Adélie Land from Dumont d'Urville Station. Four men, including C. J. Lorius as chief, participated. They did some glaciological work with accumulation measurement, took ice cores for subsequent laboratory study, studied fissures in Astrolabe Glacier, and measured the deuterium content of the water. The latter studies were arranged at the behest of the French Commissariat on Atomic Energy, to develop a method for determination of the growth of layers of snow and firn. Under the direction of A. Bauer a geodesic survey of Kerguelen Island was made, glaciological work was done on the island, the number and size of its glaciers were surveyed, and they were photographed from a helicopter. A visit to Possession Island confirmed the absence of glaciers there, and no traces of former glaciation were found.

(Ice, No. 10, July 1962)

The Twelfth French Antarctic Expedition comprised 19 wintering scientists, who intended to do considerable glaciological research. Their supply ship, the "Maga Dan" performed incidental hydrographic work.

(Antarctic, March 1962)

South African researchers undertook a traverse, on which they made glaciological and magnetic measurements, north-westward from Sanae Station. The mean, maximum, and minimum temperatures in the Sanae area in October 1961 were, respectively, -14.4°, -1.9°, and -42.9° The mean wind velocity was 35.2 km/hr, but some gusts reached 140 km/hr. Storm winds occurred on 16 days during the month, drifting blizzards on 29, and snow fell on 18 days. The expedition, which comprised 19 men, included four meteorologists, two specialists in other branches of geophysics, a geologist, a cartographer, etc.

Creation of a new South African Antarctic station, staffed by 14 men, is planned, at 70°16' S. lat. and 2°21' W. long., about 50 m above sea level.

(Antarctic, May 1962)

At the end of 1961 the Japanese Antarctic Expedition undertook a traverse from Syowa Station into the region of 75° S. lat., going 886 km inland. The Yamato Mountains were studied. In the region of 73° S. lat., a locality 2800 m above sea level was reached. The extreme southern point reached by the traverse (75° S. lat.) is 3260 m above sea level. During the 1961-1962 season only automatic meteorological instruments and a magnetometer functioned, but at Syowa Station, wintering of scientific researchers was planned for the following year. The "Soya", which came to take away the last shift of the Japanese expedition, conducted oceanographic research en route, and helicopters based upon it made an aerial photographic survey.

(Antarctic, March 1962)

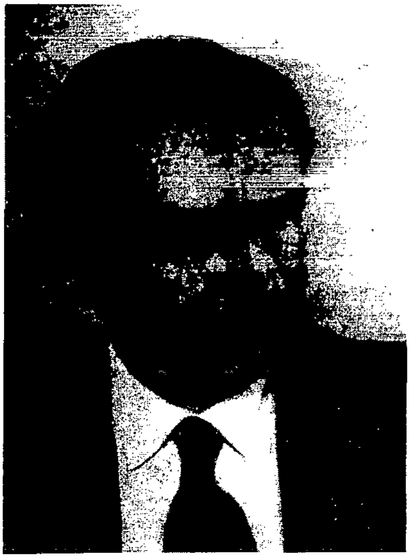
The noted Canadian polar researcher, Wilhjalmur Stefansson, who directed many exploratory expeditions in the Canadian Arctic Archipelago, died at the age of 83. Stefansson was the first to traverse the eastern part of the Beaufort Sea along the drift ice, making scientific observations en route, and to study the water area westward from Prince Patrick Island. He discovered a number of islands.

After a serious illness, Dr. E. V. Stacy, President of the International Board of Scientific Unions since 1961, died in Ottawa on 28 August, 1962. Dr. Stacy was a passionate advocate of international scientific organizations and attributed enormous importance to their capacity to further the progress of science and of mankind.

Professor Horst Philipps, Chairman of the Committee on Geodesy and Geophysics of the German Democratic Republic (East Germany), and an outstanding German scientist widely known throughout the world, died suddenly on 8 November, 1962.

Philipps was born on 29 January, 1905 in Bautzen. After finishing the gymnasium in Berlin in 1924, he entered the Physics and Mathematics faculty of Berlin University, graduating in 1930. As early as his university days he was involved in scientific activity, participating in the publication of papers on meteorology and demonstrating, in the opinion of his colleagues, an oustanding capacity to apply theoretical knowledge in practice. After leaving the university, Philipps first took a post in the Geodesic Institute of Potsdam, then took a position as Senior Assistant in the Institute of Long-Range Weather Forecasting at Frankfurt-am-Main, where for the most part he studied quantitative and qualitative aspects of the earth's thermal and radiation balance.

At this time he was preparing his highly-esteemed paper on problems of the radiation balance, and published a paper on perturbations in the lower layers of the atmosphere due to stratospheric pressure waves. He then became Director of the Division of Long-Range Forecasting in the same Institute. Only in 1942 was he discharged by the Nazi regime from the Imperial Hydrometeorological service for an indefinite period, because of his antifascist and antimilitarist convictions.



Horst Philipps, 29 January, 1905 to 8 November, 1962.

After the war Philipps became Director of the Theoretical Meteorology Division of the former Meteorological Observatory in Potsdam, where he produced a number of brilliant papers on problems of thermal balance and movement in the atmosphere.

In 1950 he was appointed to the post which he occupied until his death — Director of the Hydrometeorological Service of the GDR, founded upon his initiative. Since 1949 he had been a professor at the Humboldt University of Berlin, and in 1955 he became professor and department chairman at Karl Marx University in Leipzig. When Philipps was appointed to his responsible post, which involved carryong on the work of such great meteorologists as Bjorkness and Veikman, his own great contributions to the development of hydrometeorology were taken into account. The government of the GDR thought highly of Philipp's service. He was awarded a Humboldt Medal and judged worthy of a Government Prize.

Philipps thoroughly understood the importance of international cooperation in geophysics and was enthusiastic about the International Geophysical Year. In particular because he was secretary of the GDR National IGY Committee, the observations made by the GDR in all divisions of the program, both at stations and outside the country, were first-class.

Horst Philipps was a ready participant in the activities of the Special IGY Committee and the International Geophysical and Geodesic Union. He attributed great importance to the increasing of collaboration among geophysicists within the framework of Europe and Asia, considered as a single region, and did a tremendous amount of work on the preparation of regional conferences and development of ways for the most effective cooperation among the countries of the region. In Horst Philipps Soviet geophysicists have lost a sincere friend, who did a great deal to strengthen the scientific ties between the USSR and the GDR.

On the day of his death the Soviet Geophysical Committee sent an expression of its sympathy to his family, to the National Committee on Geodesy and Geophysics of the GDR, and to the Directors of the German Academy of Sciences in Berlin.

International geophysical calendar for 1963*

January

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

February

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

March

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

April

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June

						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August

				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October

		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November

					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

January, 1964

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

- 17 (circled) .... Regular World Day (RWD)
- 20 (boxed) .... Day of Solar Eclipse
- 7 (underlined) .... Day with Unusual Meteor Current Activity
- 18 (heavy circle) .... RWD of Special Importance
- 24 (diamond) .... Day of Rocket Wind Sounding
- 15 (triangle) .... Regular Meteorological Day
- 16 17 18 19 (bracketed) .... World Geophysical Interval

* Legend explained in more detail in the explanation of the 1962 calendar, printed in "Geofizicheskii Byulleten', No. 12.

Exception — the World Geophysical Intervals (MGI). It is proposed to use them for certain experiments which cannot practically be performed over an extended period of time, but which can give very valuable statistical data on seasonal variations. The choice of intervals was made with a view to the interest in the basis of the meteorological disciplines. In 1963 the intervals are put at about a month after the equinox and solstice, i.e., in the periods when seasonal variations of several meteorological phenomena in the upper layers of the atmosphere are most sharply expressed. Coordinated international meteorological programs envisage supplementary synoptic observations by means of rocket launchings and sounding balloons during the IGY. Observation of ionospheric drifts and wind measurements in the upper layers of the atmosphere are other similar programs.

EXPLANATORY LIST OF ABBREVIATED NAMES OF USSR INSTITUTIONS, JOURNALS, ETC., APPEARING IN THIS BOOK

Abbreviation	Full name (transliterated)	Translation
AN KazSSR	Akademiya Nauk Kazakhskoi-SSR	Academy of Sciences of the Kazakh SSR
AN SSSR	Akademiya Nauk SSSR	Academy of Sciences of the USSR
GUGMS	Glavnoe Upravlenie Gidro-meterologicheskoi Sluzhby	Main Administration of the Hydrometeorological Service
IAU (MAS)	Mezhdunarodnyi Astro-nomicheskii Soyuz	International Astronomical Association
IFZAN	Institut Fiziki Zemli imeni O. Yu. Shmidta (Akademin Nauk SSSR)	Institute of the Physics of the Earth im. O. Yu. Shmidta (Academician of the Academy of Sciences of the USSR)
IGGU (MGGS)	Mezhdunarodnyi Geodezi-cheskii i Geofizicheskii Soyuz	International Geodesic and Geophysical Union
IZMIRAN	Institut Zemnogo Magnetizma, Ionpfery i Rasprostraneniya Radiovoln Akademi Nauk SSSR	Institute of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propaga-tion of the Academy of Sciences of the USSR
KAE	Kompleksnaya Antarktiches-kaya Ekspeditsiya	Comprehensive Antarctic Expedition
MGK	Mezhduvedomstvennyi Geofizicheskii Komitet	Joint Geophysics Committee
MGU	Moskovskii Gosudarstvennyi Universitet	Moscow State University
MKG	Mezhdynarodnyi Komitet po Geofizika	International Committee on Geophysics
MTsD	Mirovoi Tsentr Sbora i Khraneniya Dannykh	World Center for the Collection and Storage of Data
NIIGAiK	Novosibirskii Institut Inzhenerov Geodezii Aerofotos"emki i Kartografii	Novosibirsk Institute of Geodetic, Aerial Survey and Cartographic Engineers
VNIIGeofizika	Vsesoyuznyi Nauchno-Issledovatel'skii Institut Geofizicheskikh Metodov Pazvedki	All-Union Scientific Research Institute of Geophysical Methods of Exploration
VSEGEI	Vsesoyuznyi Geologcheskii Nauchno-Issledovatel'skii Institut	All-Union Geological Scientific Research Institute
YaFSO	Yakutskii Filial Sibirskii Otdelenie	Yakutsk Branch of the Siberian Division

4.00

Cover printed in Jerusalem, Israel

NASA-TTF-283
TT 65-50117